9950-464

DRL NO. 106

DRD NO. SE-2

DOE/JPL-955403-80/1

Distribution Category UC-63

FINAL REPORT

DESIGN, FABRICATION, TEST, QUALIFICATION AND PRICE ANALYSIS FOR "THIRD GENERATION" DESIGN SOLAR CELL MODULES

PREPARED BY

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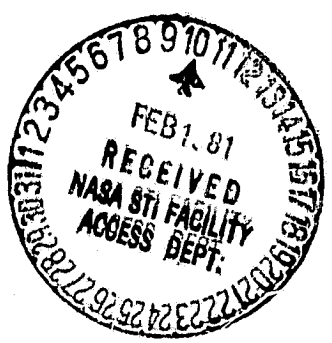
FOR

LOW COST SOLAR ARRAY PROJECT (L.S.A.)

DOCUMENT NO...SPC455-19

DATE.....September 15, 1980

REVISION.....APPROVED



"The JPL Low-Cost Solar Array Project is sponsored by the U.S. Department of Energy and forms part of the Solar Photovoltaic Conversion Program to initiate a major effort toward the development of low-cost solar arrays. This work was performed for the Jet Propulsion Laboratory, California Institute of Technology by agreement between NASA and DOE."

CONTENTS

1.0 INTRODUCTION

This final design report for the Low Cost Solar Array Block IV Program has been prepared in response to the Contract Data Requirements List (CDRL) Item #6 DRD NO. SE-2. The report includes an updated program plan showing the task descriptions depicting the work, progress, achievements and the cause of any deviations from the original plan (SC-1), and how this impacted on the original schedule of the program. In addition there is an update documenting all design alterations made during the pre-production phase and a complete up to date set of Engineering and Manufacturing Documentation (CM-1).

The purpose of this report is to document the work performed through the final design and the test results of the modules developed under this contract, and to use this documentation to further the understanding and evolution of solar cell module design.

2.0 UPDATED PROGRAM PLAN

The original program plan included a Work Breakdown Structure, Task and Sub Task descriptions delineating the objectives and relationships of each element to the total program, and a milestone schedule showing the period during which each task would be performed. This update will follow the same format as above, only the descriptions will delineate the actual achievements and any deviations from the original tasks and the relationship each element had on the total program. These written descriptions will be further documented on the milestone schedule.

The purpose of the work in the original plan was to explore, design, develop, test and deliver to JPL 1000 watts of prototype flat plate, photovoltaic modules appropriate for use in applications in the 20 to 500 kilowatt range and which show potential for meeting the 1986 cost goals. The work has been performed under this contract. This updated plans' purpose is to track the activities which occurred in the course of the contract and to point out what can be learned from these events to help achieve the 1986 goals of the Low-Cost Solar Array Program

2.1 WORK BREAKDOWN STRUCTURE (WBS)

The WBS for the LSA Block IV program as shown in Figure 2-1 was used during the course of the program. No variations or modifications of this item were made as it satisfied the provision of giving Solar Power Corporation's operating personnel a comprehensive view of the total program and the interrelations of its constituants. The subtasks as indicated under each of the major cost centers remained intact. The schedule for the program was directly related to these breakdowns and will depict any variations which occurred during the course of the program.

2.2 TASK DESCRIPTIONS AND UPDATE

2.2.1 TASK I - ANALYSIS AND DESIGN

Various trade-off analyses were performed as they related to design integrity, manufacturability, feasibility and costs of module components and modules to obtain an optimum module design. This included structural analysis of substrate design, chemical compatibility studies, optical enhancement analysis, and electrical performance predictions. These were presented at the PDR on August 20, 1979. At that time several concerns were expressed by JPL regarding the substrate and terminal design which were largely dimensional in nature. These were investigated and an agreeable design change was made as documented in TPR #4 SPC 455-10.

At that time efforts to fabricate a module consisting of 288 wrap-around cells and a reinforced porcelainized steel substrate were underway with a firm module design. The cells had a rectangular geometry with an active area of 22 cm^2, giving approximately 10.6 mW/cm^2 at 28°C AM 1. The circuit design was 8P x 36 series giving approximately 15 Vdc, 5 Amps at peak power. Because of the cell design i.e., wrap-around, the packing factor of the module was in excess of 96%, giving a module efficiency of > 10%. During the month of September, 1979, receipt of sample substrates took place. The deformation

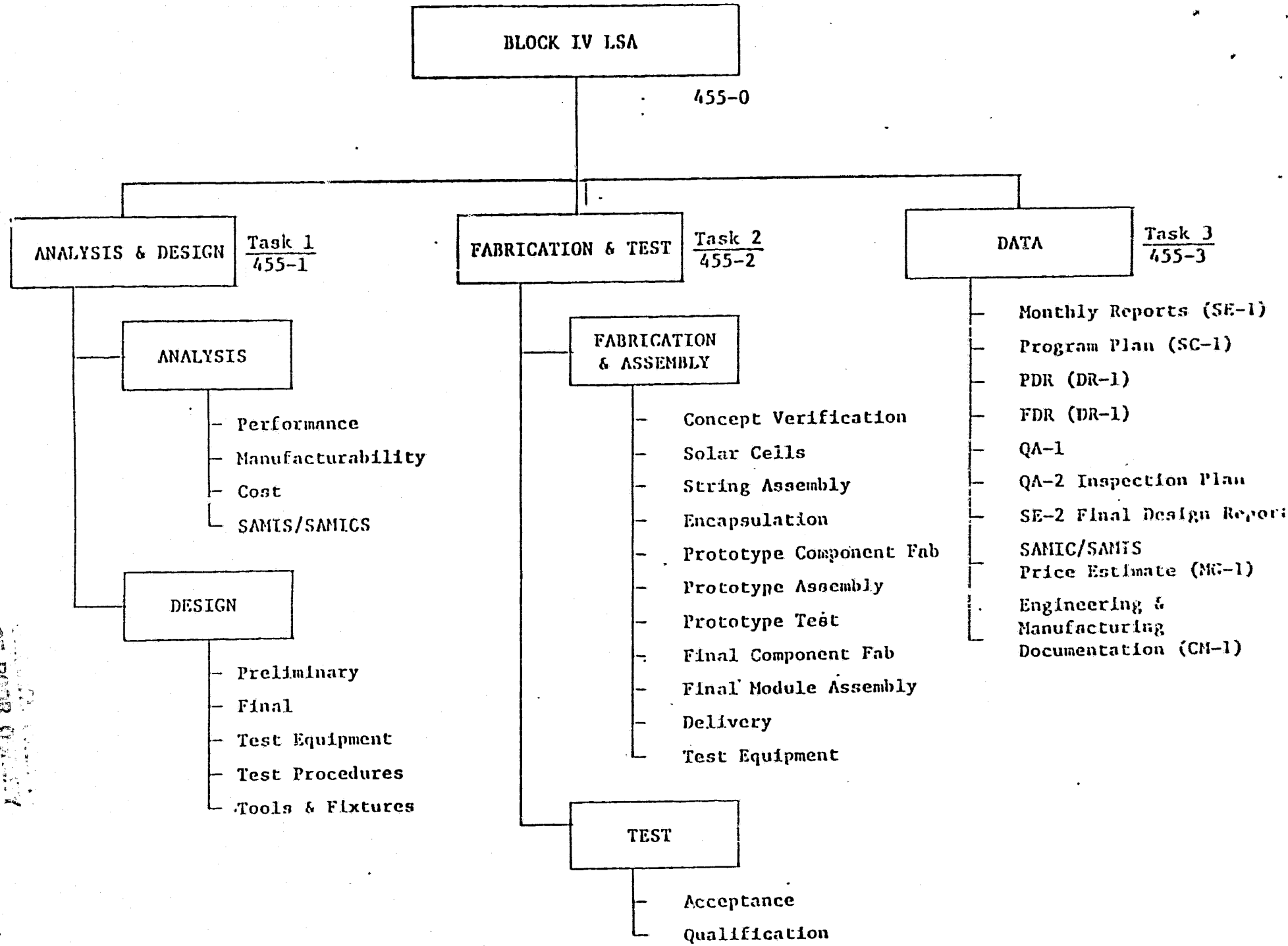


FIGURE 2-1: Solar Power Corporation Block IV LSA Program Work Breakdown Structure

along the perimeter was totally unacceptable, showing dimensional gradients in excess of 0.375 inches across the length (See Figure 2-2). The primary cause was determined to be a combination of built-in stress during spot welding of stiffeners, and the asymmetric thermal stresses incurred during and after enamel firing of the substrate. During October the first prototype module was fabricated. The lamination fixturing and process sequence went smoothly and produced a good module (See Figures 2-3, 2-4). The production of wrap-around cells was consistently difficult regarding an acceptable yield so front contact cells were incorporated for this first prototype with 35 rather than 36 cells in series. Further receipt of substrates proved to show random warpage between spot welds, although some substrates were marginal. The approach at this time was to control the spot welding dwell time and temperature to obtain an even distribution of stress across the substrate, and thus eliminate any physical warpage.

During November, 1979, all component parts for module fabrication were received except for cells and acceptable substrates. A marginal substrate and the available wrap-around cells were used to produce a module for display at the 14th P.I.M. (See Figure 2-5). The fixturing and lamination cycle worked smoothly producing a good module. At this time several design changes were proposed. First to eliminate spot welding the stiffeners to the substrate, and mechanically fasten them on as a post assembly operation. The stresses between spot welds were effectively distorting the 19 gauge steel pan during the porcelain firing operation. Secondly to incorporate an acrylic layer between the cells and the substrate, since hi-pot test failure was occurring due to pin hole existance in the porcelain surface. An additional revision occurred in December, 1979. The top layer of acrylic showed signs of embrittlement after routine cleaning with Isopropyl alcohol. Other prototype modules also showed a surface crazing effect after short steady state storage. Llumar was decided on as the replacement surface material.

FIGURE 2--2

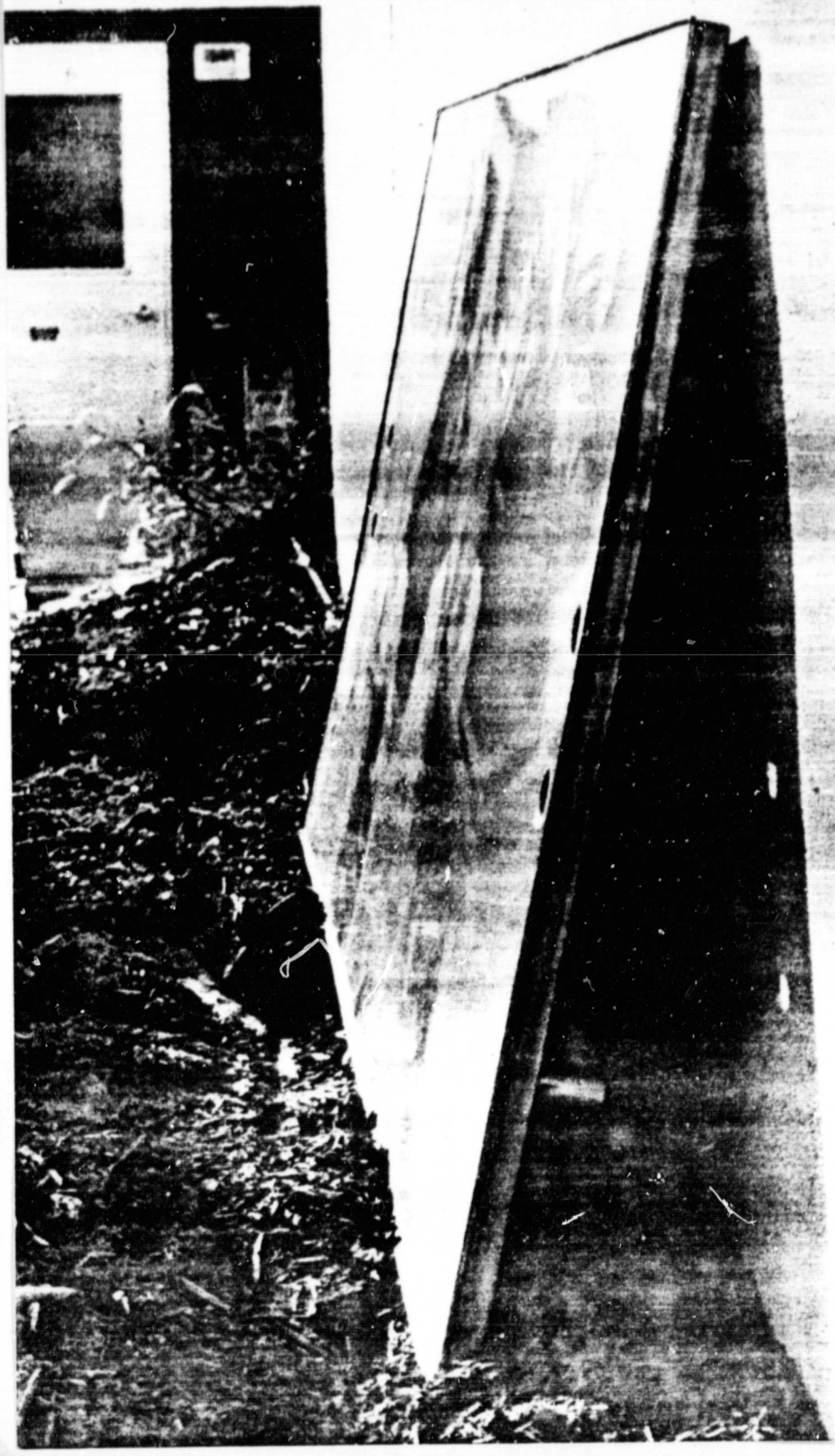


FIGURE 2-3

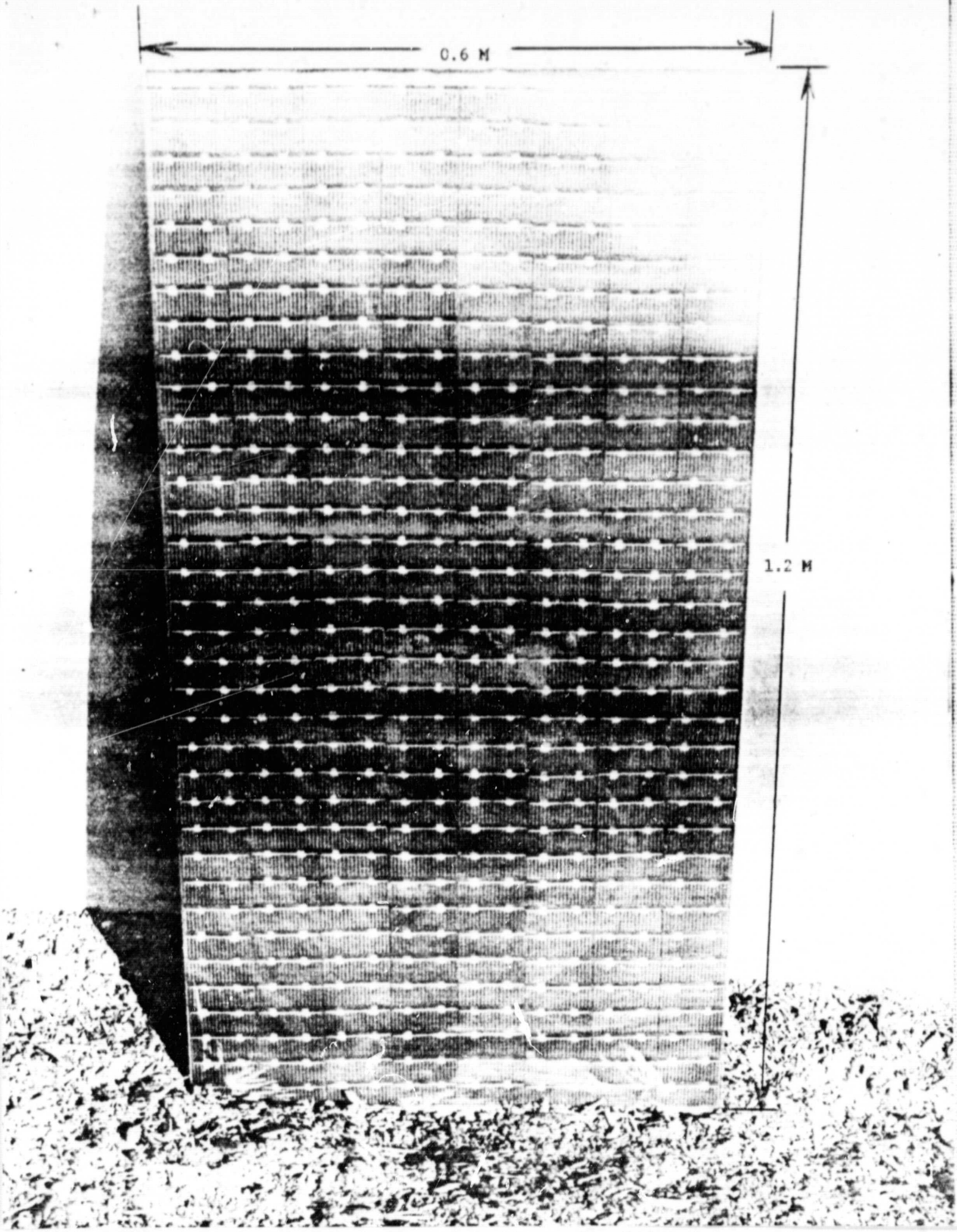


FIGURE 2-4

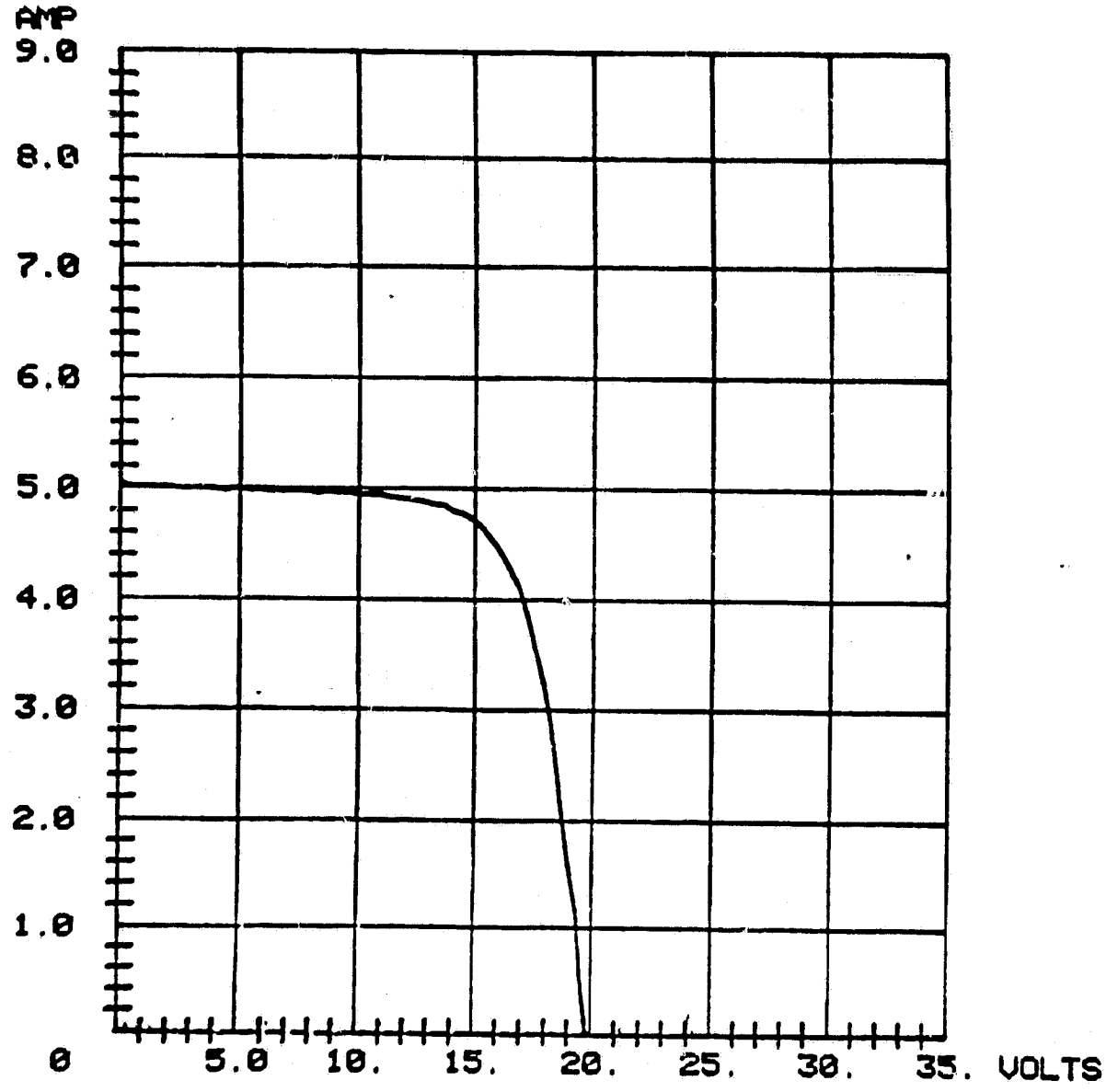
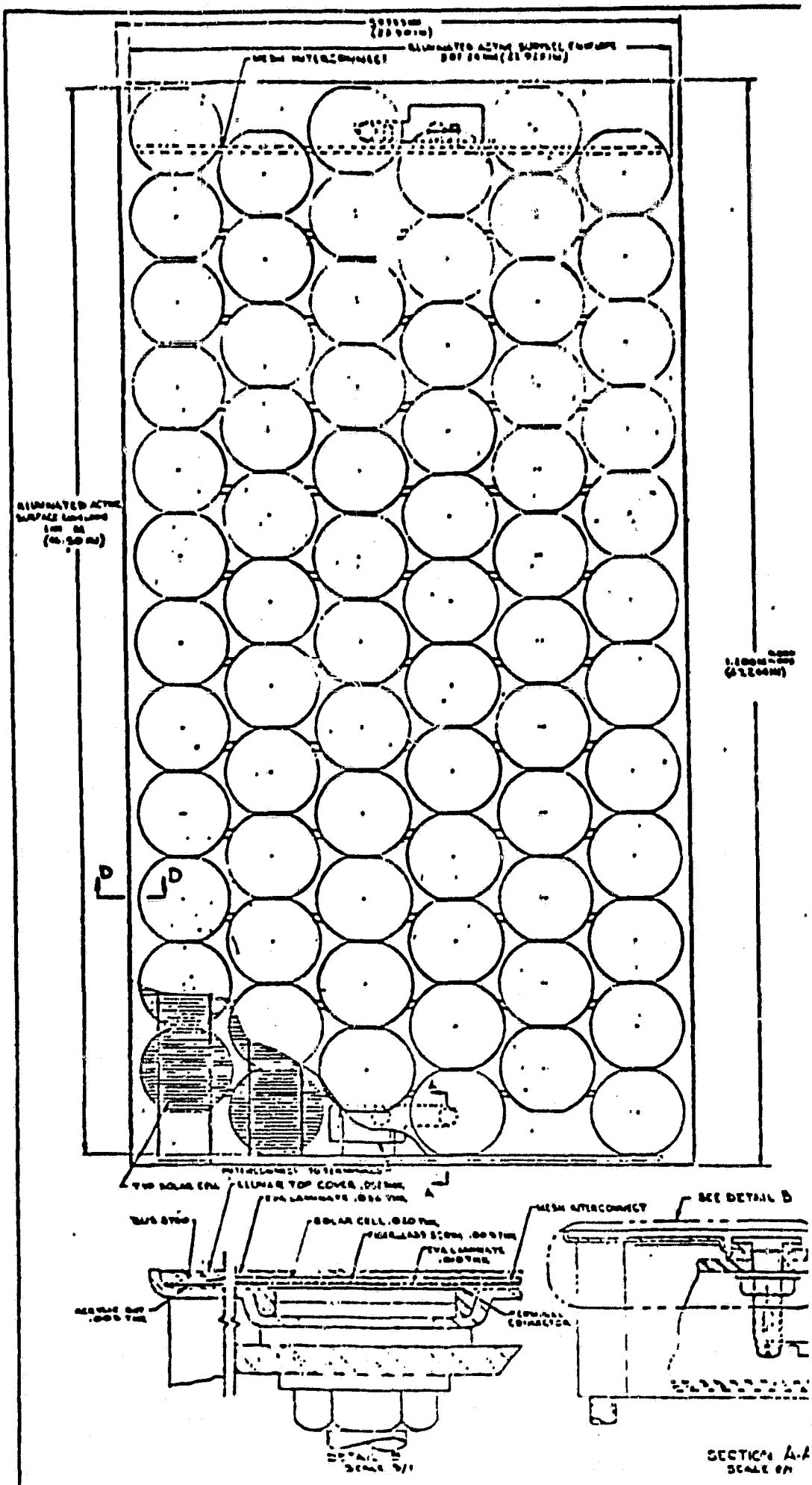


FIGURE 2-6



In January, 1980 it was decided to incorporate junction boxes at the rear positive and negative terminations to protect the output terminals from corrosion. Design of this addition took place at that time. Also in January, samples of the two component substrates were received and proved to be flat and of excellent quality. During February, 1980 all component parts for module fabrication were in-house. Cells remained the one outstanding part necessary before pre-production fabrication could begin.

Due to the poor yield and thus high cost of wrap-around cells, in March, 1980 it was recommended that a new cell and string design be incorporated into the module. The 288 wrap-around cells in a 8P x 36S configuration were replaced by 72, 100 mm modified circular cells in a 6P x 12S configuration. This new circuit design produced approximately 5 Vdc, 12.6 Amps at peak power. The module packing factor went from 96% to 76%, giving a module efficiency of $\approx$ 8%. (See Figure 2-6). The cells included integral copper Invar buss bars (4) across the front and rear of each cell. This design change greatly improved the electrical reliability of the cell string as it drastically reduced sensitivity to cracked cells and the usual resulting power degradation. This change was proposed to JPL and approval was made after the 15th P.I.M.

The month of April, 1980 was spent documenting all component parts of the new cell string, ordering parts, and fabricating cells. In May, 1980 the first group of pre-production modules were delivered to JPL. In June and July the remaining modules under this contract were fabricated and acceptance tested. During August and September four (4) modules were undergoing Qualification Testing at AVCO Labs, while the remainder were at JPL facilities for test and evaluation.

2.2.2 TASK II - FABRICATION AND TEST

Module fabrication and test took place during and after Task I to verify the design and manufacturability and to produce 1000 watts (minimum of 900 watts) of modules for delivery to JPL. Since the module design included many new concepts and materials, extensive component concept verification had to take place. This activity began at the outset of the contract by fabricating small but representative module constructions, and testing these per JPL Doc. 5101-16 Rev. A. The original design included shingled rectangular solar cells, with interconnects running from top to bottom. Initial fabrication and test of modules using this cell design were made during June and July, 1979. The results indicated that there was a compatibility problem between the cell design and module fabrication technique. Specifically, the atmospheric pressure the panel sees during lamination far exceeded the strength of the cells when arranged in a shingled fashion. An embossed base could have solved this problem, however development time to achieve this was prohibitive.

At the PDR on August 20, 1979 the original shingled cell design was replaced by a wrap-around cell concept, keeping the active area per cell relatively the same as the initial design. This achieved a flat cell string and a 36 series x 8 parallel circuit design. In-house fabrication of prototype steel substrates took place in June-July, 1979. Some slight deformation of the .042 thick steel surface sheet was apparent after welding, but was acceptable per prints. Receipt of these substrates with porcelain coating took place in September, 1979. Extensive edge warpage occurred during the firing of the glass coating. At that time the addition of a perimeter flange was made to the design, and additional prototypes were ordered.

During the next several months, efforts centered around wrap-around cell fabrication, prototype module fabrication and substrate evaluation. Cell production showed marginal success primarily due to cell dicing problems. Edge effects created both unpredictable electrical characteristics, as well as physical fracture, lowering the yields to a prohibitive level. This had a direct effect on module fabrication, and slowed down the progress of process and substrate verification. Alternate cell designs were used to

determine the usability of the substrate design, which also had a yield problem.

Substrate samples recieved in January showed excellent flatness. This was primarily due to the elimination of the integral back stiffeners. Sample laminations indicated no further problems existed with the substrate design.

Upon approval from JPL for a modification in the cell string design which occurred in March, substrate pans with a white porcelain finish on the front surface were ordered. The back stiffeners were already in-house. During May, the first pre-production modules were produced (See Figures 2-7, 2-8). By the end of May the first quantity of modules were Acceptance Tested and delivered to JPL. During the next two months, the remaining modules were fabricated, Acceptance Tested, and delivered to JPL, with exception of four (4) modules to be Qualification Tested at AVCO Systems in Wilmington, Mass.

Feedback from JPL regarding the qualification tests was disconcerting. The electrical degradation of any one module was not more than 3.5%, however, other problems were occurring. The two primary occurrances were with additional cell cracking, and delamination. The former became evident after Thermal Cycling and Hail Impact tests. The latter was due to early primer failure which was corrected at SPC prior to showing up at JPL. Both of these problems contributed to non-qualification of the module. However, the primary factor seems to have been cell cracks in excess of the agreed upon maximum.

The positive point to mention is electrical performance. No modules seemed to have failed because of power degradation. This is of primary importance. Correction of the cell cracking would most likely solve the problems necessary to pass the Qualification Tests. Unfortunately all the mechanics of the stress causing cell fracture are not fully understood at this time, and so no positive recommendations can be made. However the hail impact failure can most likely be solved by decreasing the pottant thickness below the cells and thus prevent deflection of the silicon at impact.

FIGURE 2-5

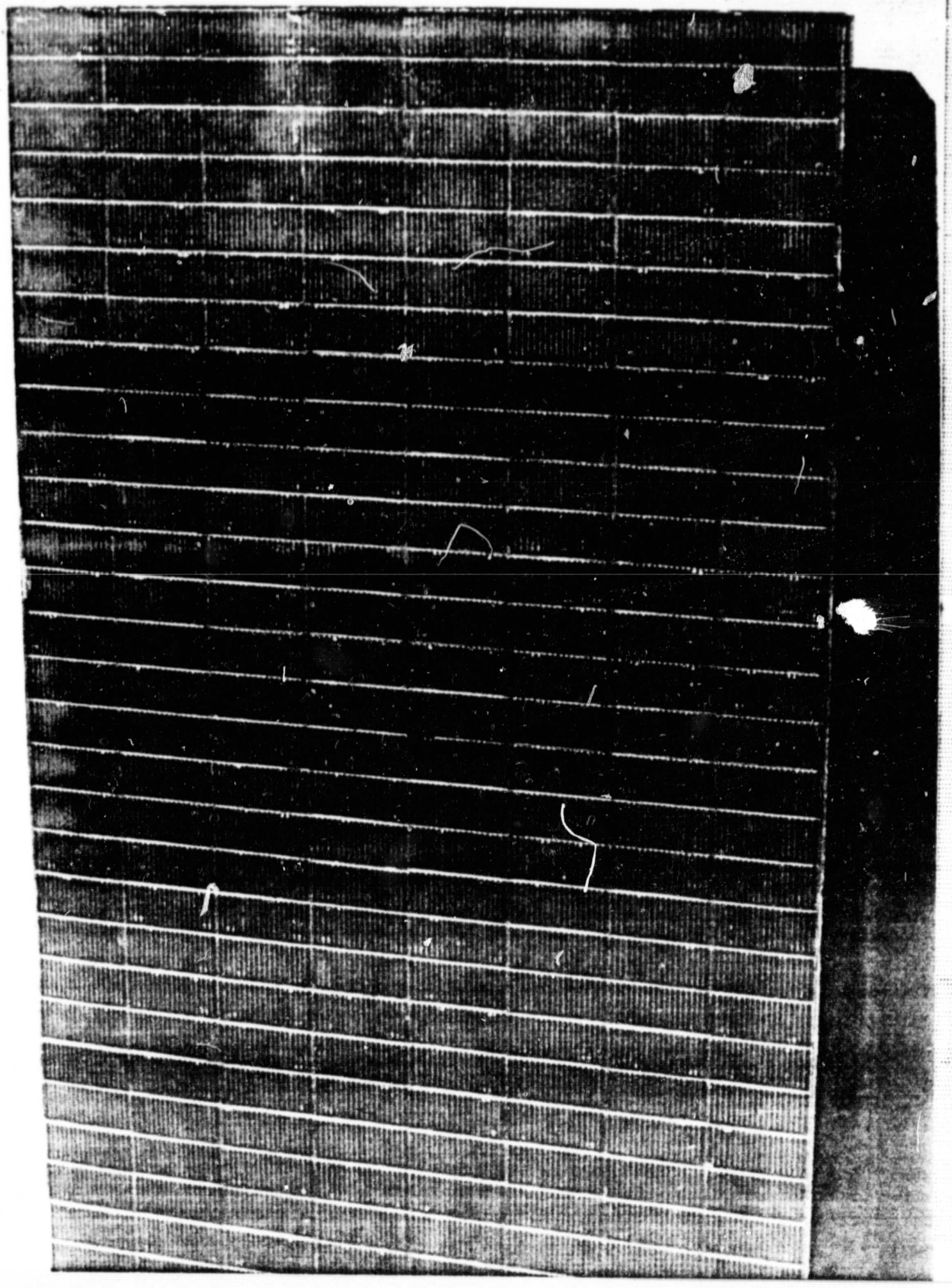


FIGURE 2-7

FINAL MODULE DESIGN

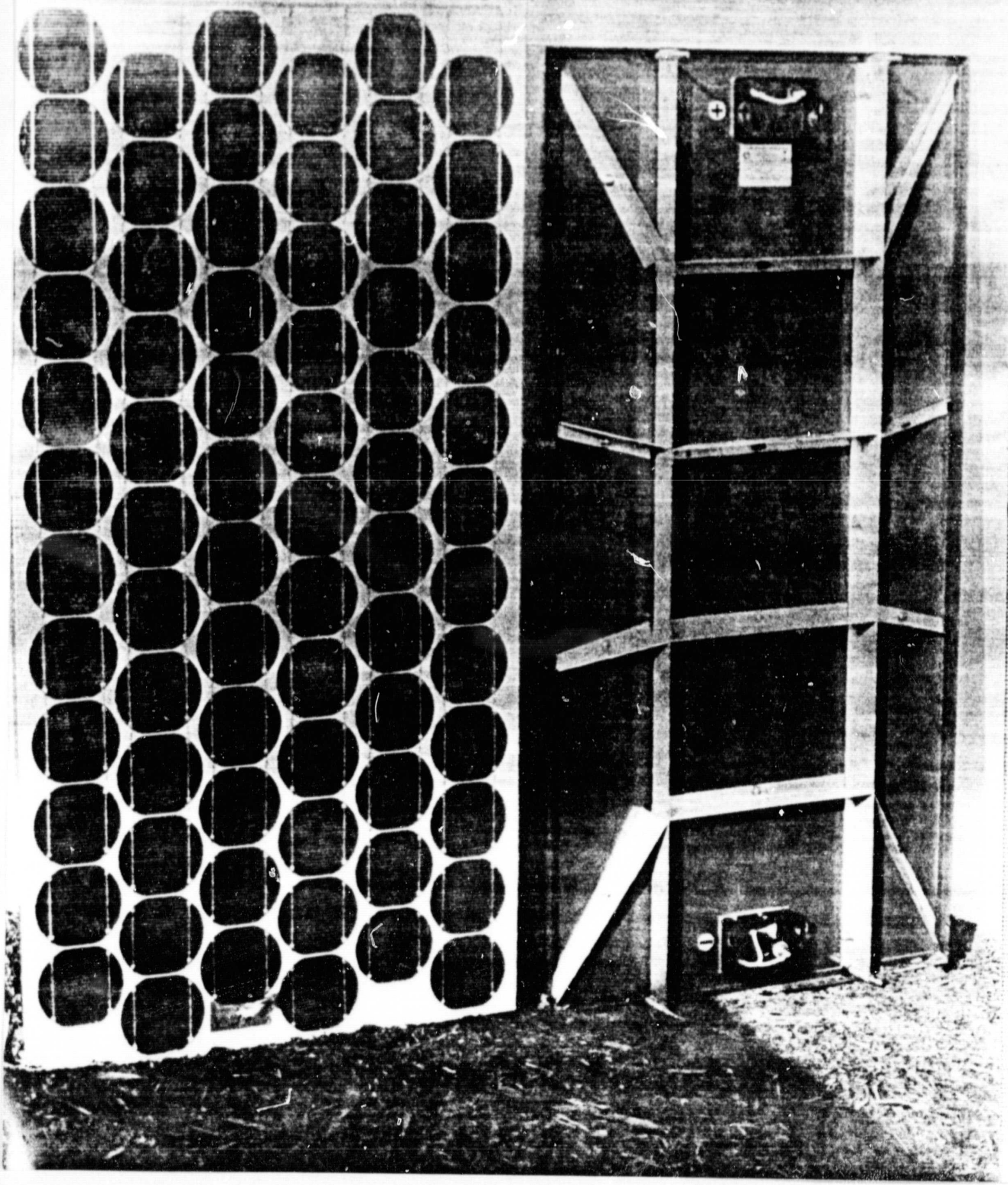
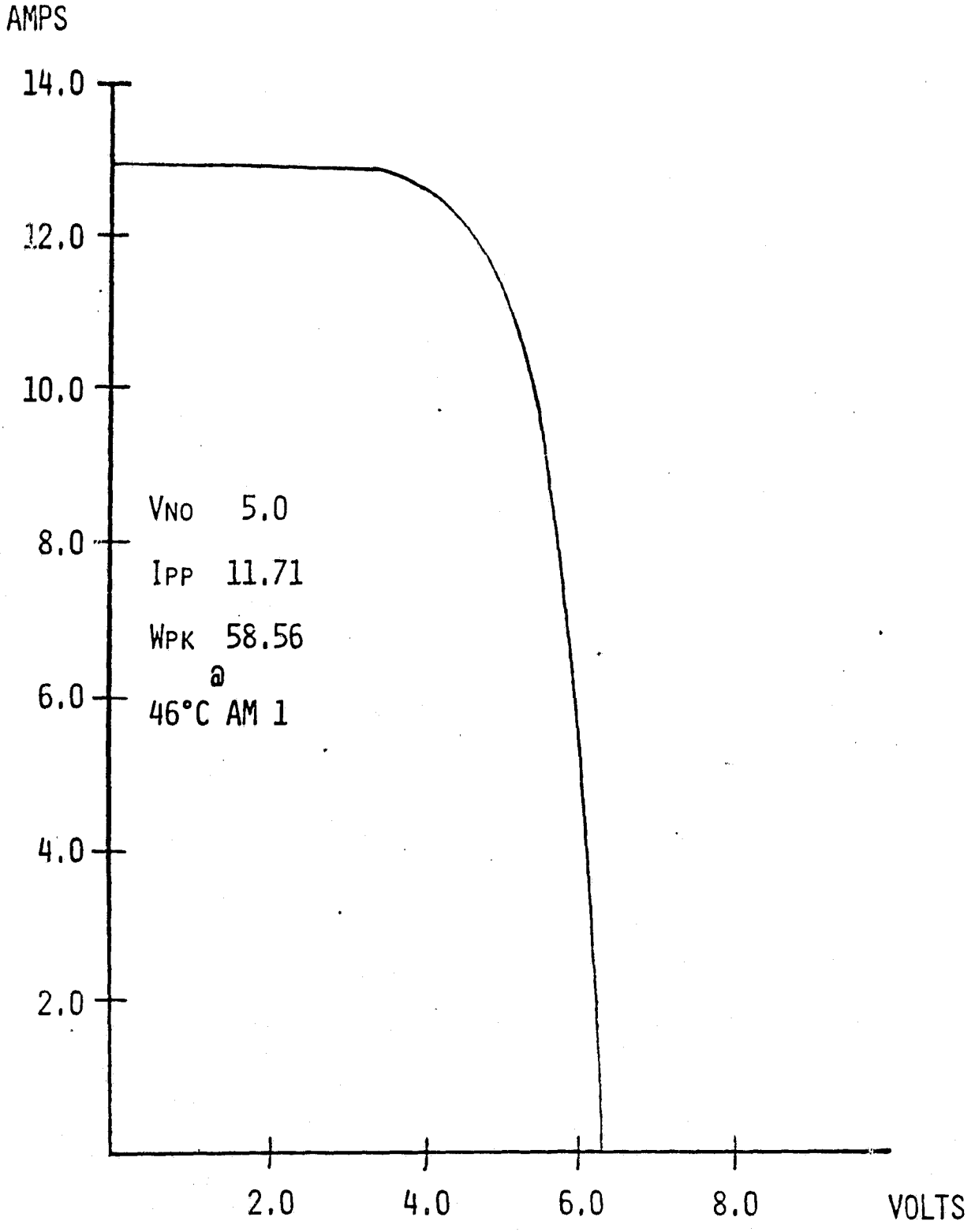


FIGURE 2-8

TYPICAL PRE-PRODUCTION MODULE

I-V CURVE



2.2.3 TASK III - DATA

This task encompassed the effort necessary to create, edit, and publish the documents required by the Contract Data Requirements List (CDRL). The requirements were generally broken up by JPL into three categories: Preliminary, Pre-production, and Production. All preliminary and pre-production requirements are complete. The Production category is not applicable due to mutual agreement between JPL and SPC Block IV Program personnel. There were several changes in the schedule for delivery of data during the course of the program. These are shown in Section 2.3 Program Schedule and Update. A total of thirteen (13) Monthly Technical Progress Reports were submitted to JPL under this task. The Data Delivery Packages for all seventeen (17) modules (975.5 watts) which outlined the Q.C. and electrical performances have been forwarded along with the modules to JPL. All other documentation required under this contract including Manufacturing and Engineering Packages have been submitted per program requirements (See Figure 2-9).

During the course of the program a total of ten (10) TDMs were received by SPC from JPL. These were either for approvals, disapprovals, recommendations, or clarifications of data. TDM #7 which was for approval of reference cell calibration values was never fully agreed upon. Our power readings disagreed with JPL's by about 3%. Various discussions took place to resolve this discrepancy, however a disposition was never made.

Qualification Testing and Documentation from AVCO Systems in Wilmington, Mass. was also never completed. It was agreed upon by both JPL and SPC that further testing of the modules was not necessary, since failure occurred at the JPL Environmental Testing Labs. The tests at AVCO would have been completed before such a decision was made, however test chamber problems, and instrumentation difficulties prevented completion. It was discovered that since our cell string was a 6 parallel x 12 series configuration, it was very difficult to monitor power loss due to an open circuit occurring during testing. The threshold of change in the electrical performance was not much different between an open circuit and

temperature excursion effects. Therefore any one or two points becoming an open circuit in the module had a negligible effect on performance relative to thermal cycling conditions. In fact, analysis of our circuit configuration per JPL circuit design optimization manual proved to show a total of 4 cells could be open circuited in our module with less than a 10% power loss.

2.3 SCHEDULE AND UPDATE

The program schedule is shown in Figure 2-10, 2-11, and 2-12 in milestone chart form. The three figures correspond to the three major tasks described in Section 2.2, and include subtask milestones. Each subtask where applicable is charted relative to start date, scheduled completion date and actual completion date.

These charts were used by Solar Power Corporation operating personnel and Management to control and monitor the program's progress. The charts were also the primary baseline around which the Monthly Technical Progress Reports (DRL Item #2 DRD NO. SE-1) were written.

TASK 3

DATA SUBMITTAL SCHEDULE

CDRL Item No.	DRD No.	TITLE	DATE DUE	COMPLETION DATE
1	SC-1	Program Plan	6/27/79	6/25/79
2	SE-1	Technical Progress Report	15th of each month	7/80
3	DR-1	Design Review Data Package		
		(A) Preliminary Design Review ...	8/17/79	8/29/79
		(B) Final Design Review	11/9/79	11/19/80
4	CM-1	Engineering & Manufacturing Documentation		
		(A) Preliminary	8/17/79	8/29/79
		(B) Pre-Production	9/21/79	6/6/80
		(C) Production (proposed)	11/9/79	N/A
5	QA-1	Inspection System Plan		
		(A) Preliminary	8/17/79	8/29/79
		(B) Pre-Production	9/21/79	6/6/80
		(C) Production	11/9/79	N/A
6	SE-2	Final Design Report		
		(A) Draft	11/9/79	11/19/80
		(B) Approved	2/8/80	
7	MG-1	SAMICS/SAMIS Price Estimate	11/9/79	10/1/80
8	QA-2	Delivery Data Package	With each module	9/80

FIGURE 2-9: Data Submittal Schedule

FIGURE 2-10

CONTRACT IDENTIFICATION: DESIGN, FABRICATION, TEST, QUALIFICATION AND PRICE ANALYSIS OF "THIRD GENERATION" DESIGN SOLAR CELL MODULES (LSA BLOCK IV)

DRL NO. 106

DRD NO. SE-1

CONTRACTOR: SOLAR POWER CORPORATION

CONTRACT NO: 955403

PROGRAM SCHEDULE - TASK 1: ANALYSIS & DESIGN

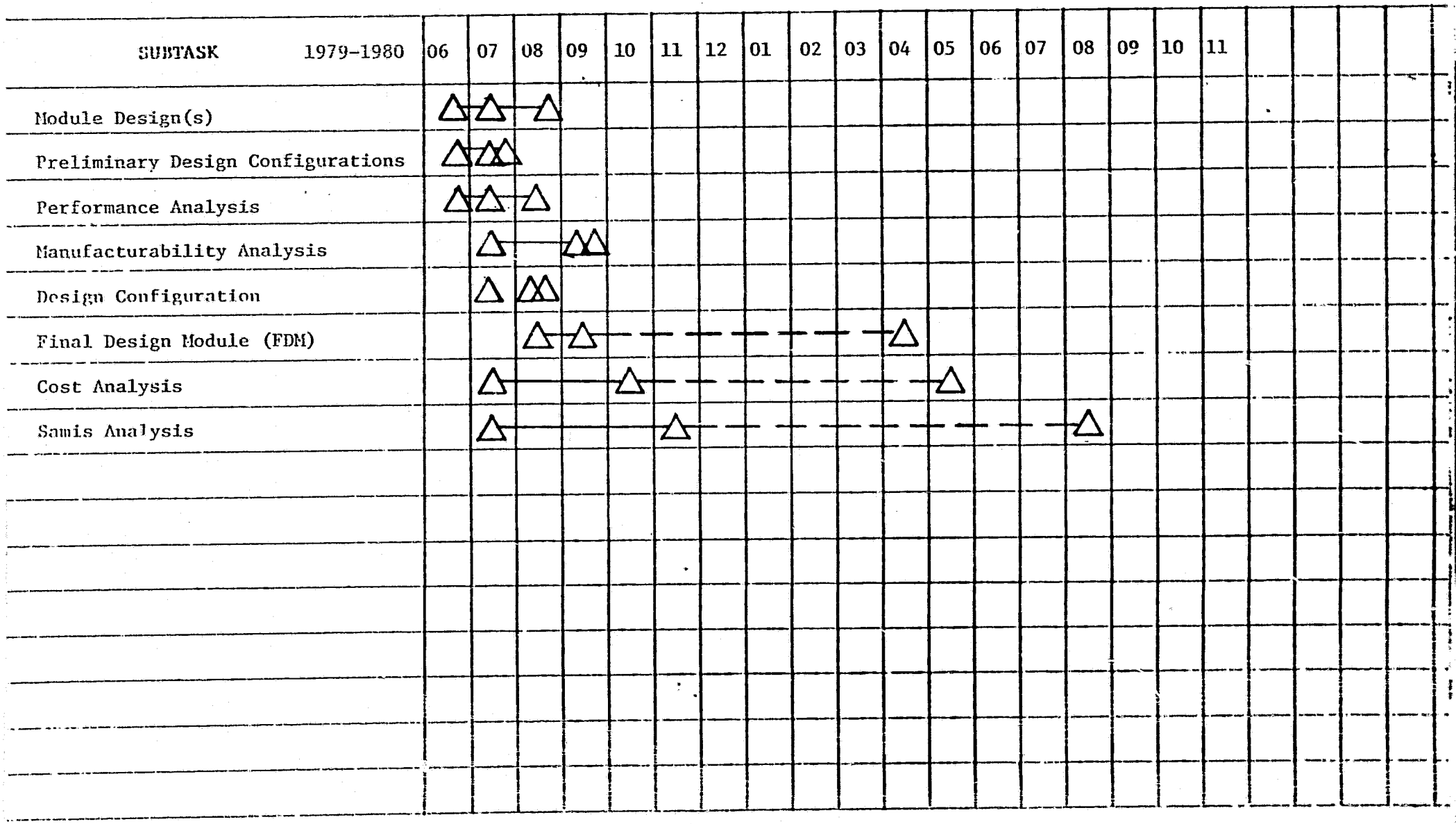


FIGURE 2-11

CONTRACT IDENTIFICATION: DESIGN, FABRICATION, TEST, QUALIFICATION AND PRICE ANALYSIS OF "THIRD GENERATION" DESIGN SOLAR CELL MODULES (LSA BLOCK IV)

DRL NO. 106

DRD NO. SE-1

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CONTRACT NO: 955403

PROGRAM SCHEDULE - TASK 2: FABRICATION & TEST

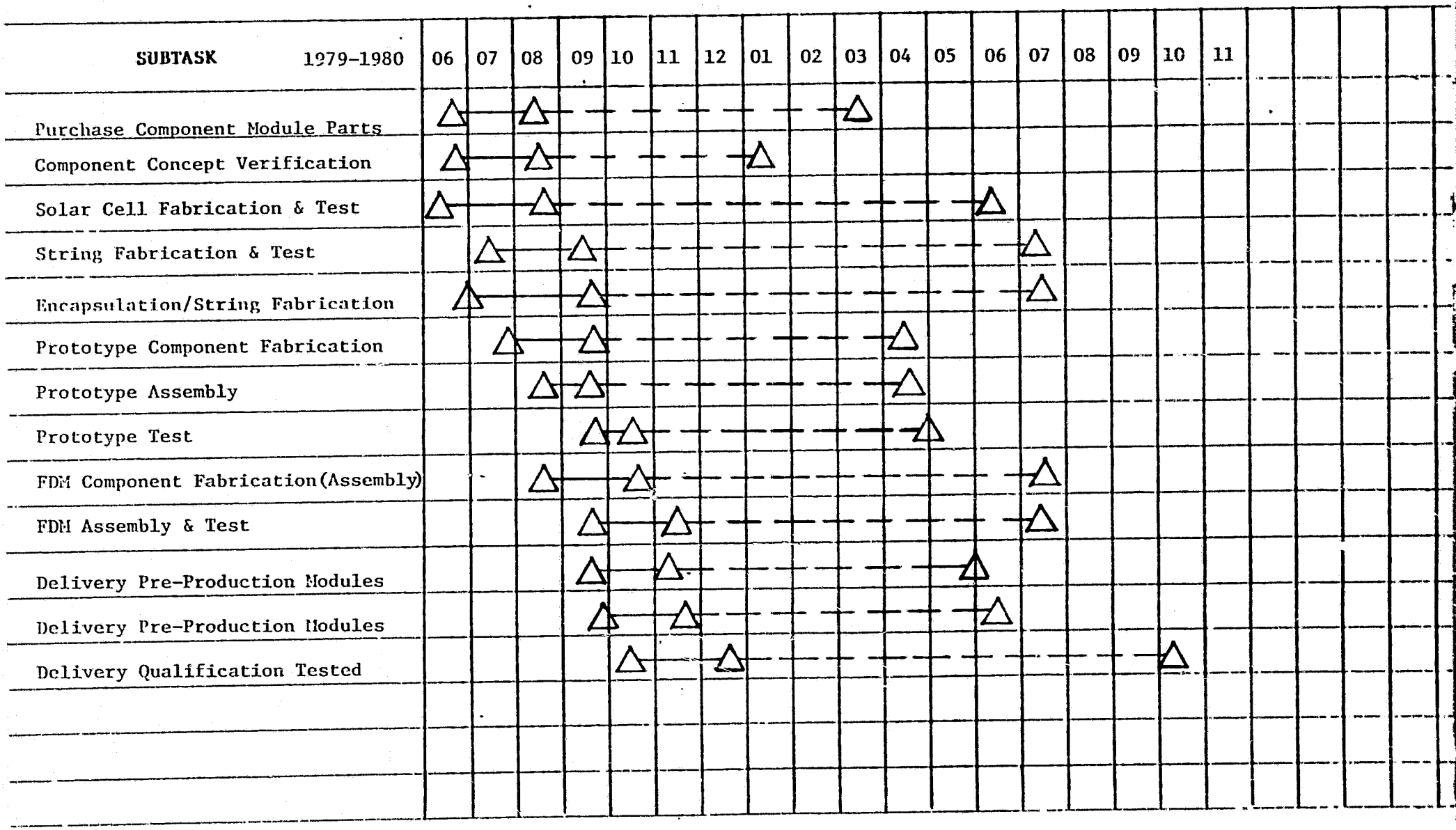

FIGURE 2-12

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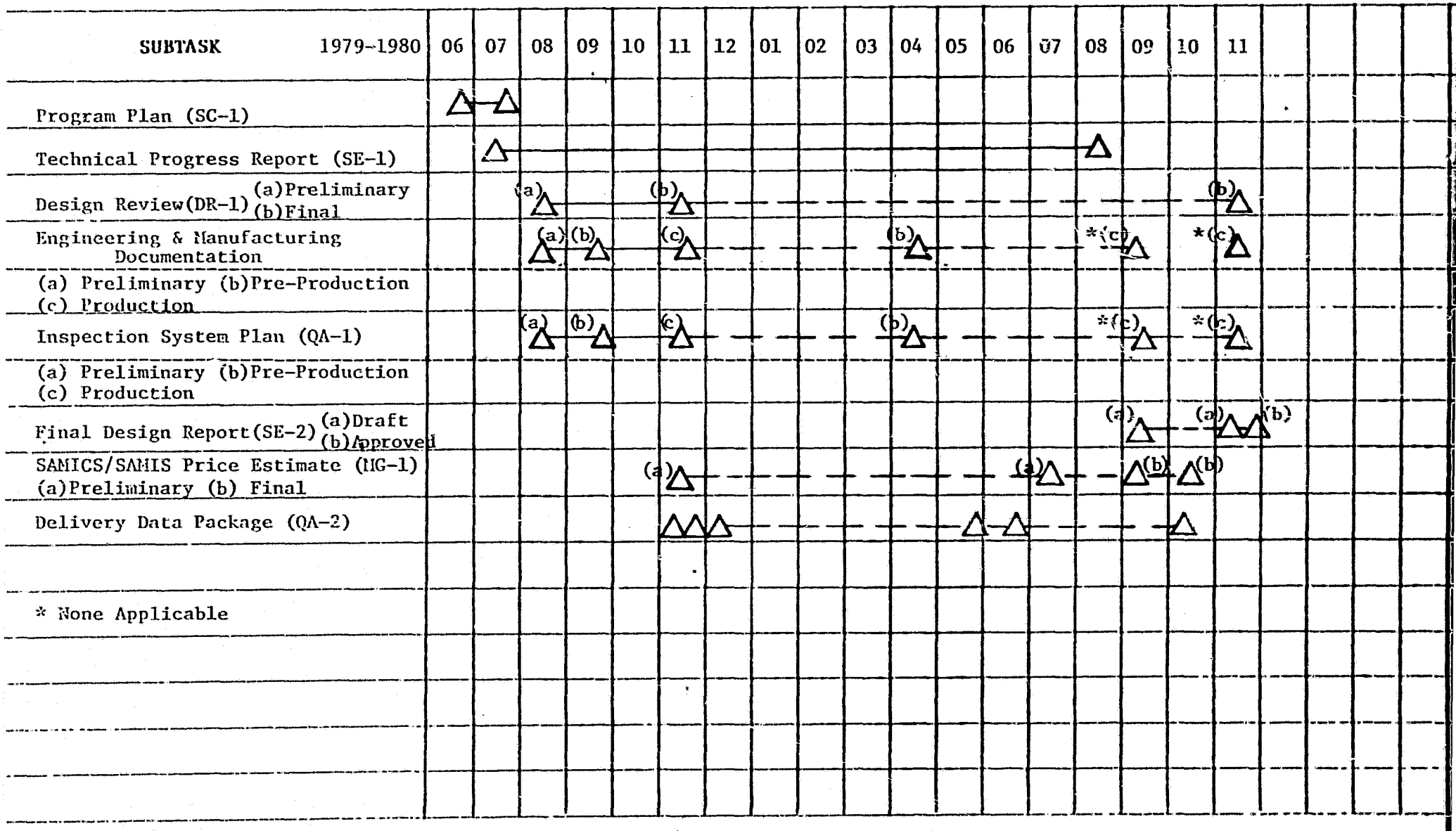
DRL NO. 106

DRD NO. SE-1

CONTRACTOR: SOLAR POWER CORPORATION

CONTRACT NO: 955403

PROGRAM SCHEDULE - TASK 3: DATA



3.0 PRE-PRODUCTION DESIGN ALTERATIONS

During the course of the Pre-production Phase of the program which essentially was between September 1979 and June 1980, various design alterations took place. These changes were based on component verification analyses, and feedback recommendations from JPL personnel. Table 3-1 lists the evolution of the design changes, and the impact they had on the program.

3.0 PRE-PRODUCTION DESIGN ALTERATIONS

ORIGINAL APPROVED DESIGN	PROBLEMS ENCOUNTERED	DESIGN ALTERATION	EFFECTIVENESS	COMMENTS
Gusset & Longeron Stiffeners integrally welded to substrate	Sever Random Warpage	Stiffener unit attached to substrate with fasteners after lamination	Warpage minimized	Modified Stiffeners made out of aluminized steel
Porcelain as dielectric insulator from steel substrate	Leakage > 50μA at voltage < 2000 Vdc	3 Mil acrylic layer added	Breakdown leakage < 50μA At voltage ≥ 2000 Vdc	This change added an extra layer of scrim under cells
1 layer of EVA below cells	Cell breakage during lamination	2 layers of EVA below cells	Cell cracking minimized at lamination step	May be cause of Hail Impact Test failure
3 Mil acrylic top sheet	Embrittlement	Llumar top sheet 2 Mil	Crazing eliminated	
Wrap-around cell and 8P x 36 Series string	Low yield electrically/ Labor intensive	Integral cu/Invar bussed 100 mm cells 6P x 12S	High yields Low sensitivity to cracks	Original design was 288 rectangular cells New design is 72 modified round cells
Black porcelain finish on substrate front surface	High thermal absorptivity	White high gloss finish	Reflective enhancement Low absorptivity WRT black	This overall module package demonstrated an NOCT ≈ 42°C
Bare terminal studs	Probable corrosion	J-Box.	Encased terminals	J-Box is usually potted

4.0 ENGINEERING & MANUFACTURING DOCUMENTATION

This section of the Final Report includes Assembly and Detail Drawings of the pre-production module and its component parts and a manufacturing plan describing and illustrating the work flow during module fabrication.

The following documents are included in this package per DRD No. CM-1.

1.	Manufacturing Plan & Flow Chart	SPC-455-5
2.	Interface Control Drawing	E-10445 Rev. H
3.	High Denisty Module Ass'y	E-5175 Rev. J
4.	Module Pan Ass'y	D-10400 Rev. F
5.	Structural Ass'y	D-10491 Rev. A
6.	Mounting Stud	B-10408 Rev. A
7.	Terminal	B-10409 Rev.
8.	Terminal Insulator	B-10410 Rev.
9.	Threaded Rod	B-10412 Rev.
10.	Mesh Interconnect	B-10446-3 Rev. B
11.	Top Cover - Llumar	A-10447 Rev. B
12.	EVA Laminate	A-10448 Rev. B
13.	Scrim Fiberglass	A-10449 Rev. A
14.	Label	A-10458 Rev. B
15.	Junction Box Modified	B-10529 Rev. A
16.	Dielectric Layer	A-10530 Rev. A
17.	Solar Cell Block IV	C-10555 Rev. A
18.	Terminal Interconnect Strip	B-10556 Rev. A
19.	Bus Strip	B-10557 Rev. A
20.	Solar Cell Interconnect Bars	B-10558 Rev. A
21.	Solar Cell Bottom Interconnect Bar	B-10559 Rev.
22.	Cell Bus Strip	B-10598 Rev.
23.	Diode Mounting Bracket	B-10568 Rev. A

Solar Power Corporation

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TWX 710-348-0602

DRL NO. 106

DRD NO. CM-1

BLOCK IV SOLAR CELL MODULE DESIGN AND TEST

FOR

INTERMEDIATE LOAD CENTER APPLICATIONS

CONTRACT NO. 955403

Manufacturing Plan

APPROVALS:

David A. Ditts
SPC Program Manager

Document No...SPC-455-5
Date.....September 17, 1979
Revision.....Pre-Production

BRANCH OFFICES
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CONTENTS

1.0 INTRODUCTION

This Manufacturing Plan for the Low Cost Array Block IV Program has been prepared in response to the Contract Data Requirements (CDRL) Item #4, DRD No. CM-1. The flow chart and accompanying block descriptions document the process steps and inspection points required to produce an Intermediate Load Center, Block IV Photovoltaic Module.

2.0 RECEIVING

Fabricated parts and raw materials required in the manufacture of the module are checked against appropriate documents and specifications (Purchase Orders, Engineering Drawings, etc.). Parts and materials found to be in compliance are then sent to the stockroom inventory.

3.0 STOCKROOM

Approved fabricated parts and raw materials are kept in inventory to be drawn out for production use as required.

4.0 CELL PROCESSING

Inventoried raw silicon wafers are processed into finished photovoltaic cells, including cutting for non-circular cells. A solar cell production traveller covering the appropriate specifications and processes is originated during this process step. This traveller is sent to Quality Assurance and becomes part of the permanent production documentation. After processing, individual cells are tested for electrical and mechanical defects. All process steps during Cell Processing are considered proprietary.

5.0 CELL STRING FABRICATION

During this process step solar cells from Cell Processing and interconnects and terminals from the stockroom are joined to form a completed solar cell string. This string will be tested against performance specifications and for open or short circuited conditions. Appropriate data for the cell string is recorded on the module assembly traveller.

6.0 MODULE ASSEMBLY

During this process step the cell string is assembled with the remaining module parts (drawn from the stockroom) and prepared for module lamination. The cell string serial number and module serial number are recorded on the module assembly traveller along with other data as required.

7.0 MODULE LAMINATION

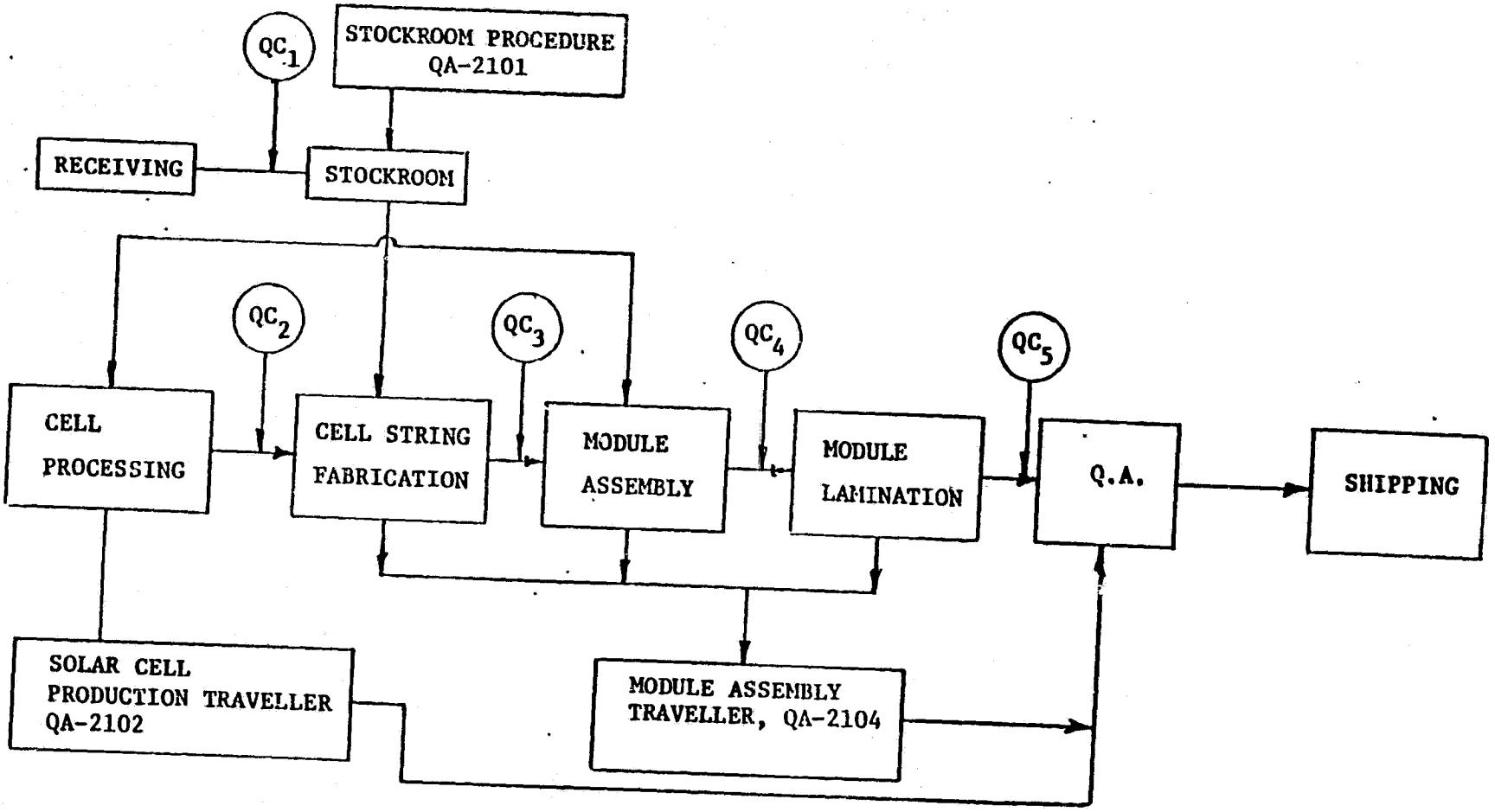
The module assembly is placed into the appropriate tooling (lamination press or autoclave) and the various layers comprising the module assembly are fused into a completed solar module. Following lamination the module will be tested electrically and mechanically.

8.0 QUALITY ASSURANCE

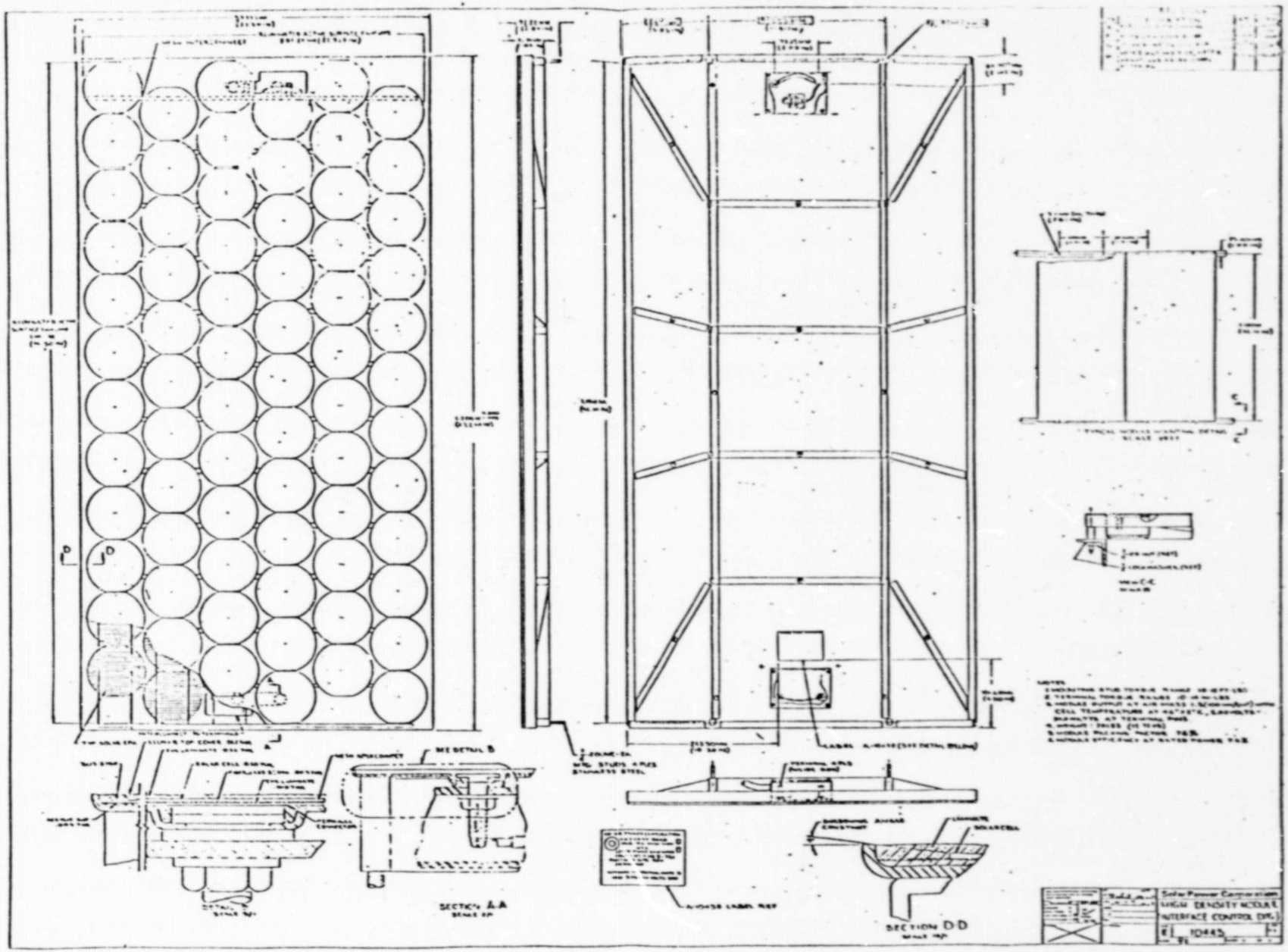
After module lamination, completed modules will be submitted to Q.A. and be electrically and mechanically tested to assure compliance with performance specifications. Electrical testing consists of testing V_{oc}, I_{sc} and P_{pk} on a LAPSS and hi-pot testing for module insulation integrity. Mechanical testing consists of visual inspection for cleanliness, workmanship standards, cracked cell, etc. Complete descriptions of the tests and testing methods are included in Q.A.-1, Inspection System Plan.

9.0 SHIPPING

Finished, approved modules are packaged into shipping containers and sent to customers, to fill existing orders. Appropriate records of module type, number of modules, shipping date, method of shipping, etc. are kept to insure complete documentation. Modules in excess of existing orders are inventoried for future orders.



MANUFACTURING FLOW CHART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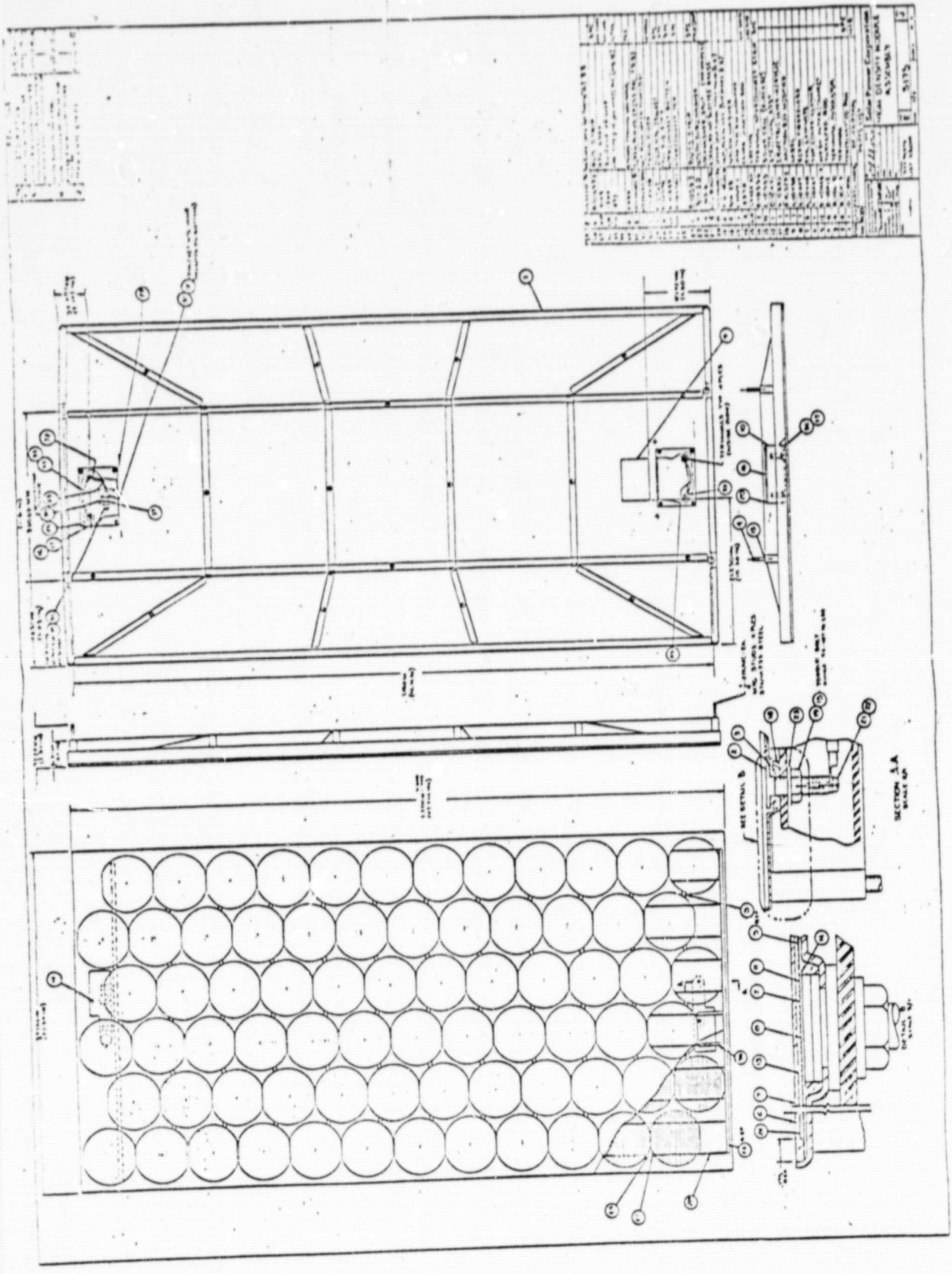
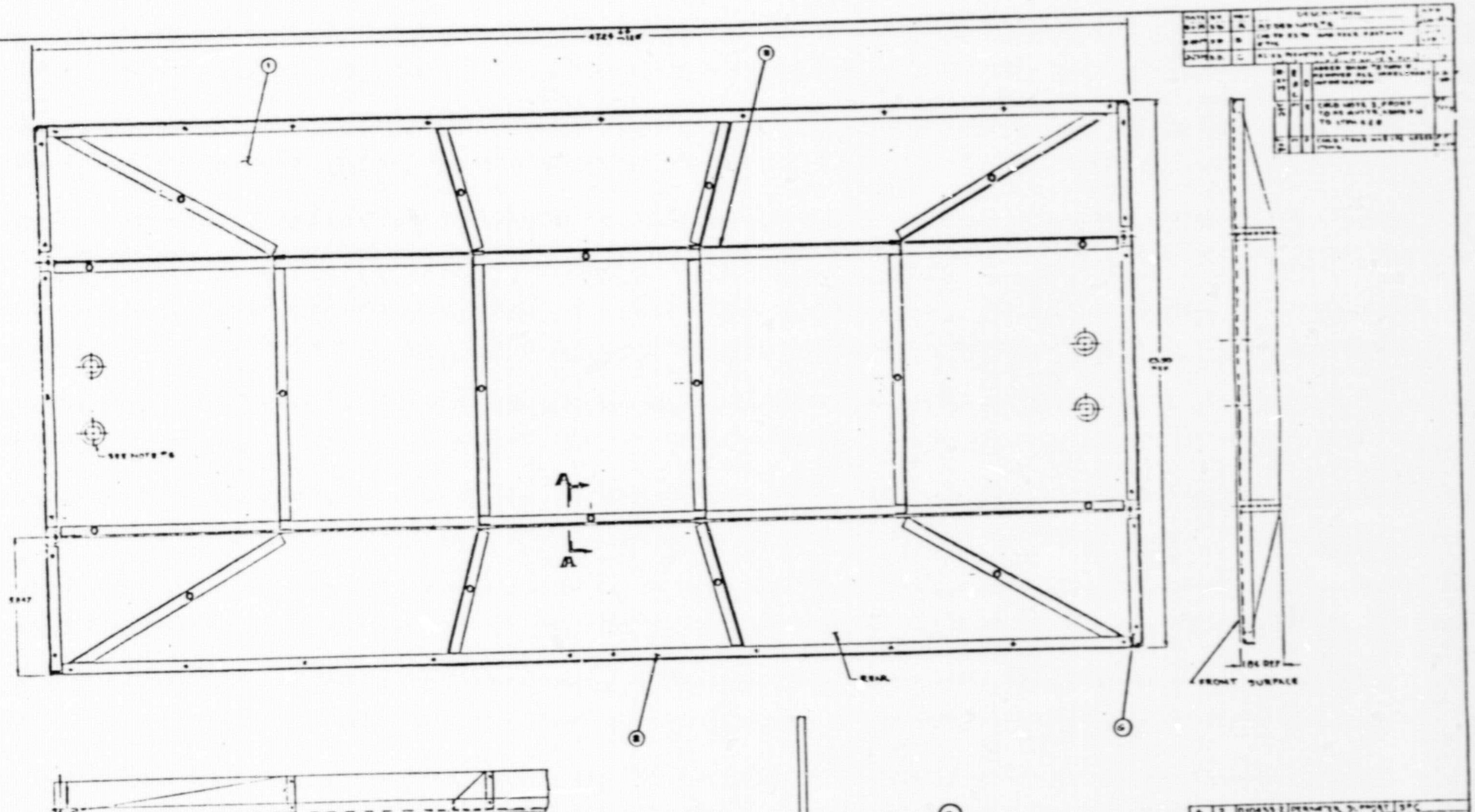
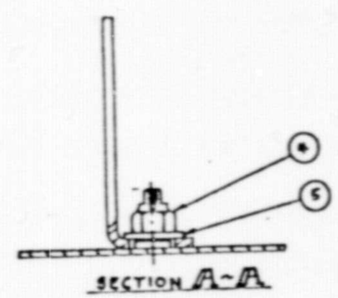




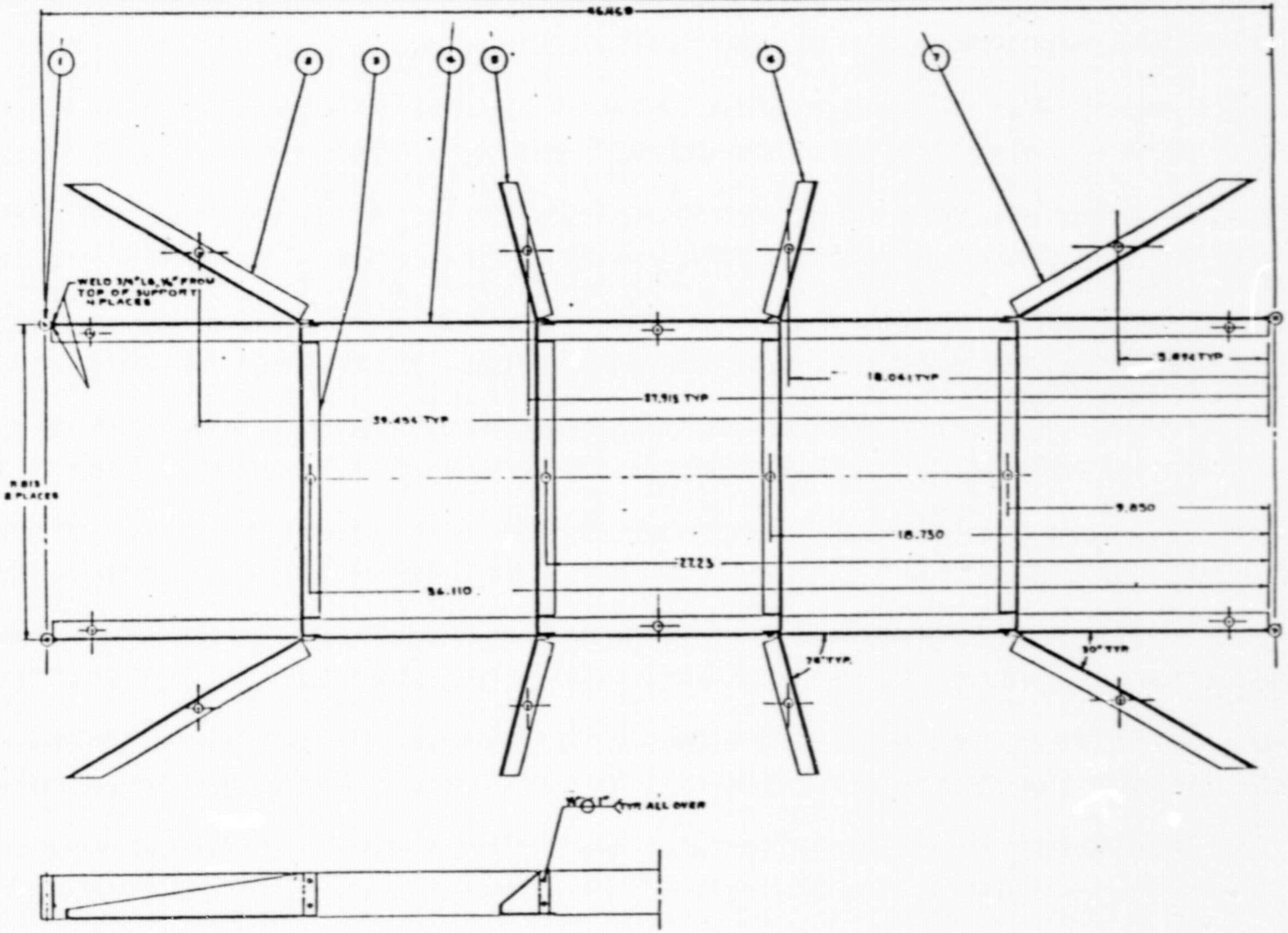


SECTION A-A
SCALE: 2:1

NOTES:
1) SPOT WELDS TO BE IN CENTER OF SUPPORT PERIMETER FLANGE AS SHOWN.
2) PERIMETER SUPPORTED PAN ASSEMBLY TO BE PORCELAINIZED. REMAINING STRUCTUIAL SUPPORT ASSEMBLY TO BE BOLTED ON FOR FINAL ASSEMBLY ONLY.
3) PORCELAIN ENAMEL COATING TO BE A TWO COAT SYSTEM 0.008"-0.016" TOTAL THICKNESS. REAR COATS TO BE SMOOTH TEXTURE BLACK (ACID RESISTANT. FRONT COATS TO BE BLACK GROUND COAT (WHITE ACID RESISTANT FINISH COAT. ALL COATS TO BE PINHOLE FREE
4) THOT ON WELD SCREWS TO BE MASKED-OFF PRIOR TO PORCELAINIZING OPERATION
5) PERIMETER SUPPORT NOT TO EXTEND PAST EDGE OF PAN.
6) HOLES TO BE BRUSHED PRIOR TO PORCELAIN FIRING (4 PLACES).
7) FRONT SURFACE SPOT WELDS TO BE GROUND SMOOTH & OVERALL PAN SURFACE TO BE FLAT WITHIN .010 .

Solar Power Corporation
HIGH DENSITY MODULE PAN ASSEMBLY PORCELAINIZED
D 10400
SEE NOTE 3

LTR	DESCRIPTION	DATE	APPROVED
A	ADDED DIM'S TO HOLES & NOTE 3	1/7/7?	



NOTES:

1) ALL WELDS TO BE SPRAYED OVER WITH ALUMINUM. COATING THICKNESS MINIMUM OF .008".
2) DEBURR AND REMOVE ALL SHARP EDGES.
3) DIMENSIONS SHOWN ARE FOR LOCATING GUSSETS BEFORE WELDING

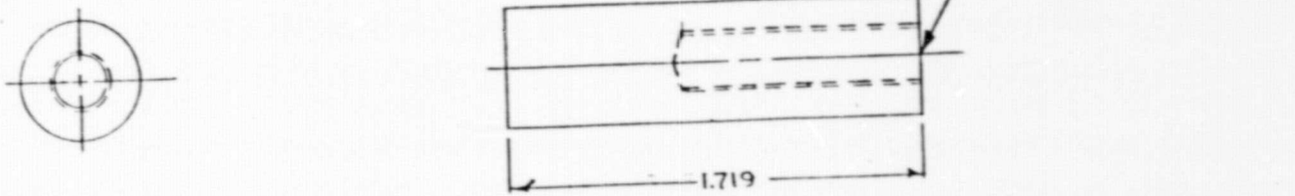
No.	QTY	PART No.	DESCRIPTION	MFG ER
7	2	C-10407	CORNER GUSSET L.H.	SPC
6	2	C-10405	INSIDE GUSSET L.H.	SPC
5	2	C-10404	INSIDE GUSSET R.H.	SPC
4	2	C-10402	CENTER SUPPORT	SPC
3	4	B-10403	CENTER GUSSET	SPC
2	2	C-10406	CORNER GUSSET R.H.	SPC
1	4	B-10408	MOUNTING STUD	SPC

Solar Power Corporation

STRUCTURAL SUPPORT ASSEMBLY

D 10491

DATE	BY	REV	DESCRIPTION	APP.
12-1877	R.A.I	A	MATERIAL CHANGE: COLD ROLL STEEL TO STAINLESS STEEL.	D D/S 1/9/80



NOTES:
1. PART TO BE FREE OF BURRS & SHARP EDGES

D-10491
USED ON

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND DEGREES

TOLERANCES		SURFACES
ANGLES	±	MICRO INCHES
FRACTIONS	±	
2 PLACE	.02	
3 PLACE	.010	

FINISH

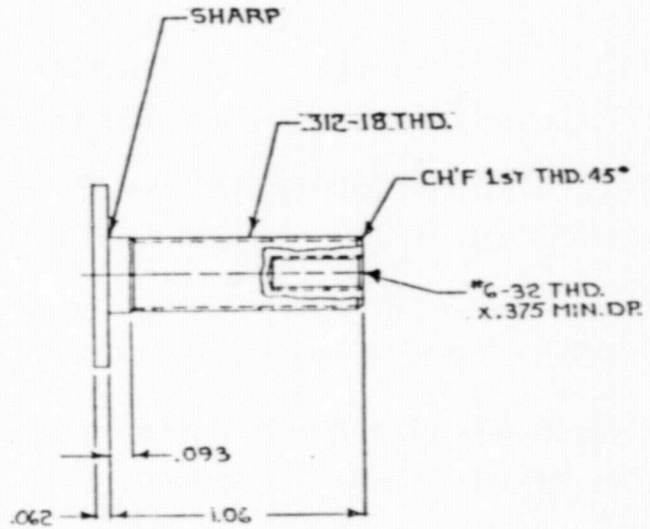
DR. S. DAVIS 5-15-79
CHK. D Davis 5-23-79
APPD.
APPD.
REL.
MATERIAL 1/2" RN STK. STAINLESS STL.

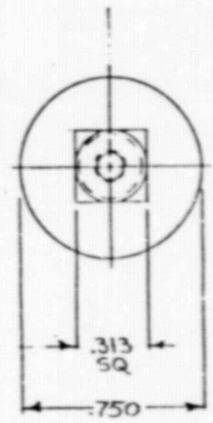
Solar Power Corporation

MOUNTING STUD

SIZE B | 10408 | REV. A

SCALE 2:1 | SHEET 1 OF 1

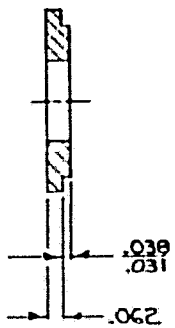


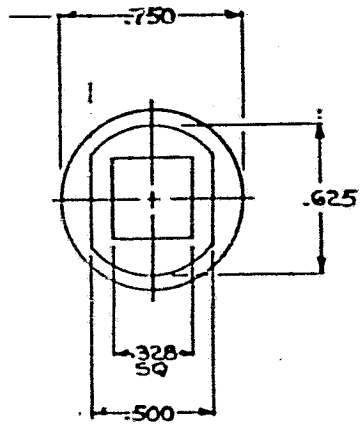


NOTES.

1. PART TO BE FREE OF BURRS & SHARP EDGES

D-5175			
USED ON			
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND DEGREES	DR. S. DAVIS 5-16-79	Solar Power Corporation	
TOLERANCES / SURFACES	CHK. D. Davis 5-17-79		
ANGLES ±~ / FRACTIONS ±~ / 2 PLACE ±.02 / 3 PLACE ±.01 / MICRO INCHES	APPD. D. Davis 5-6-79	TERMINAL	
	APPD.		
	REL.		
FINISH	MATERIAL BRASS CDA NO. 230 OR 260	SIZE B / 10409	REV.
		SCALE 2:1	SHEET 1 OF 1





NOTES:

1. PART TO BE FREE OF BURRS & SHARP EDGES

D-5175

USED ON

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND DEGREES

TOLERANCES		SURFACES
ANGLES	±	MICRO INCHES
FRACTIONS	±	
2 PLACE	±.02	
3 PLACE	±.010	

FINISH

		DATE
DR.	S. DAVIS	5-16-79
CHK.	D. Davis	5-27-79
APPD.	D. Davis	8-6-79
APPD.		
REL.		

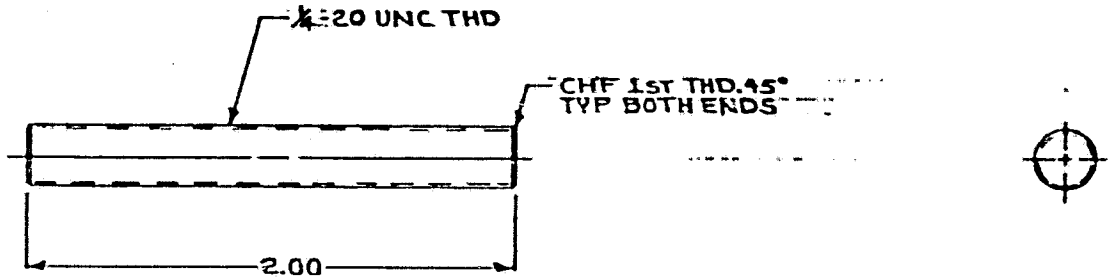
MATERIAL GENERAL PURPOSE NYLON TYPE 6 OR 6/6 WHITE

Solar Power Corporation

TERMINAL INSULATOR

SIZE		REV.
B	10410	

SCALE 2:1 SHEET 1 OF 1

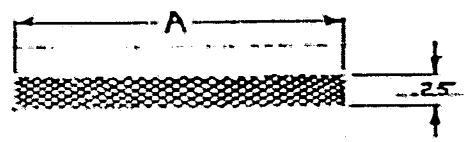


NOTES:

1. PART TO BE FREE OF BURRS & SHARP EDGES

E-5175			
USED ON			
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND DEGREES	DR. S. DAVIS DATE 5-23-79	Solar Power Corporation	
TOLERANCES: ANGLES ±, FRACTIONS ±, 2 PLACE ±.02, 3 PLACE ±; SURFACES: MICRO INCHES	CHK. D Davis 5-23-79	THREADED ROD	
	APPD. D Davis 8-6-79		
	APPD.		
	REL.		
FINISH	MATERIAL ⅛-20 TH'DED ROD 304/316 ST STL.	SIZE B	10412 REV.
		SCALE 2:1	SHEET 1 OF 1

DATE	BY	REV	DESCRIPTION	APP
[illegible]	SD	A	DELETED ITEMS 3 & 4, ITEM # 2 WAS .78	D. [illegible] 8/29/79
3-10-80	PT	B	ADDED -3	PT 3-20-80



DASH #	DIM A
-1	23.35
-2	2.16
-3	22.00
-4	

NOTES
PURCHASE FROM EXMET CORP.
#4CU 73/0

E-5175
USED ON

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND DEGREES

TOLERANCES		SURFACES
ANGLES	± ~	MICRO INCHES
FRACTIONS	± ~	
2 PLACE	±.02	
3 PLACE	± ~	

FINISH

DR. S. DAVIS DATE 8-9-79
CHK. D. Di... 8-10-79
APPD. D. Di... 8-10-79
APPD.
REL.
MATERIAL

Solar Power Corporation

MESH INTERCONNECT

SIZE B | 10446 | REV. B
SCALE 1:1 | SHEET 1 OF 1

DATE	BY	REV	DESCRIPTION	APP
8-29-79	SD	A	23.41 x 47.10 WAS 23.52 x 47.10	D. Dilts 8/
2-8-80	PT	B	WAS KORAD ACRYLIC (K201R) .005 THK	P. Tuttle

LLUMAR SHEET

.002" x 23.41." ±02 X 47.10" ±02

NOTES

1. PURCHASE FROM MADCO INC WOBURN MASS

Solar Power Corporation

SCALE: ~	APPROVED BY: D Dilts 8-10-79	DRAWN BY: S.D
DATE: 8-9-79		
TOP COVER		DRAWING NUMBER: A-10447

E-5175

USED ON

DATE	BY	REV	DESCRIPTION	APP
8-29-79	SD	A	23.41 x 47.10 WAS 23.52 x 47.10	D. Dilts 8/29
10-17-79	R.A.L.	B	ADDED .018	D. Dilts 10/17

SPRINGBORNE LAB'S EVA
LAMINATE 23.41 " x 47.10" x .018"
SHEET

NOTES
PURCHASE FROM SPRINGBORN. LABS
ENFIELD. CONN.

E-5175
USED ON

Solar Power Corporation

SCALE: ~	APPROVED BY: D Dilts 8-10-79	DRAWN BY: S. DAVIS
DATE: 8-9-79		

EVA LAMINATE | DRAWING NUMBER: A-10448 | REV. B

DATE	BY	REV	DESCRIPTION.	APP.
82979	SD	A	23.41 x 47.10 WAS 23.52 x 47.10	DDitts

FIBERGLASS SCRIM
.005 x 23.41 " x 47.10" SHEET

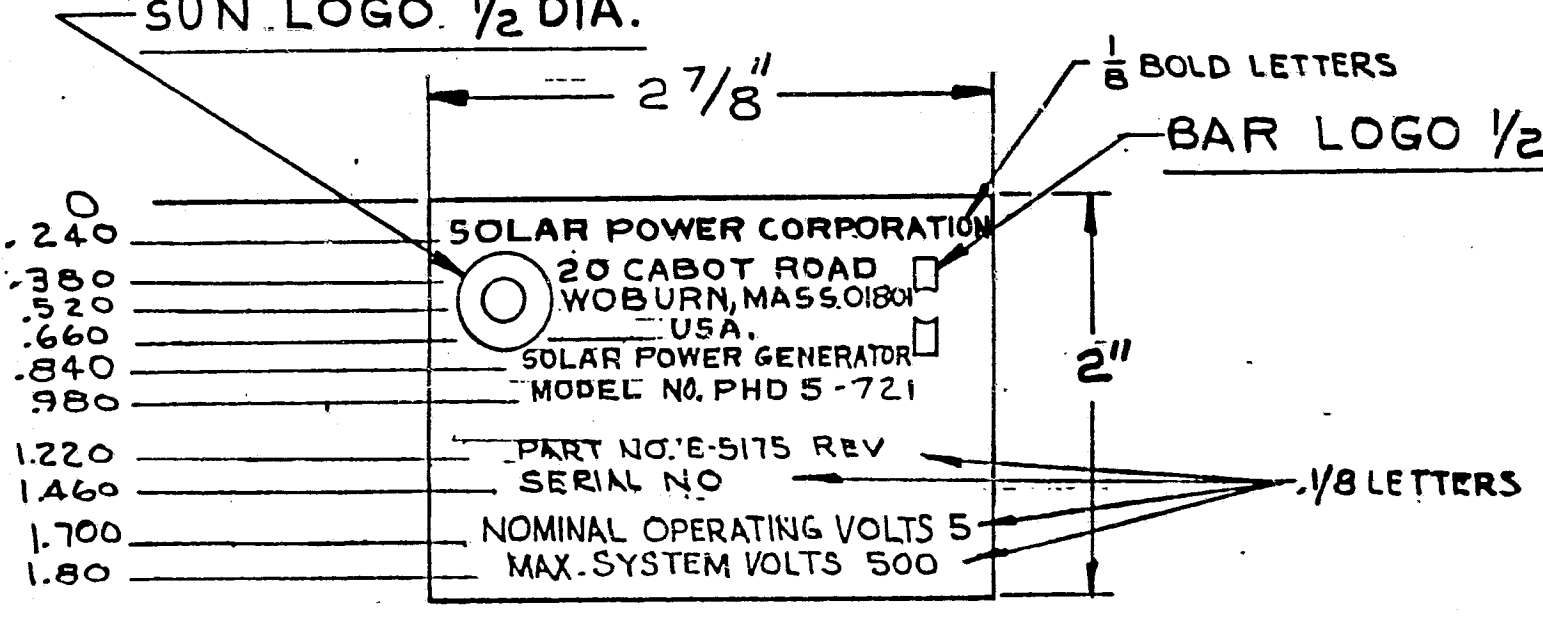
NOTES:
1. PURCHASE FROM ELECTROLOCK, INC.
P.O. BOX 368
CHARGRIN FALLS, OHIO
44022
2. MFG'ER. CRANE PAPER
DALTON, MASS.

E-5175
USED ON

Solar Power Corporation

SCALE: ~	APPROVED BY: D Ditts 8-10-79	DRAWN BY: S. DAVIS
DATE: 8-9-79		
SCRIM FIBERGLASS	DRAWING NUMBER: A- 10449	

REVISIONS			
LTR	DESCRIPTION	DATE	APPD
A	WAS MODEL 12-288 ; OPER. VOLT WAS 15 REVERSED BOTTOM LINES; ADDED DIM. TAKEN FROM TAG	3/20/80	P. Thrall
B	ADDED PART NO; MOVED S/N DOWN	5/29/80	P Thrall



NOTES:

1.) MATERIAL: .005 THICK ALUMINUM, DEAD SOFT.

2.) COLOR: BLACK LETTERS, NATURAL ALUMINUM BACKGROUND.

3.) PRESSURE SENSITIVE ADHESIVE SHALL BE APPLIED TO ENTIRE BACK.

4. UNLESS NOTED ALL LETTERS TO BE .08 HIGH

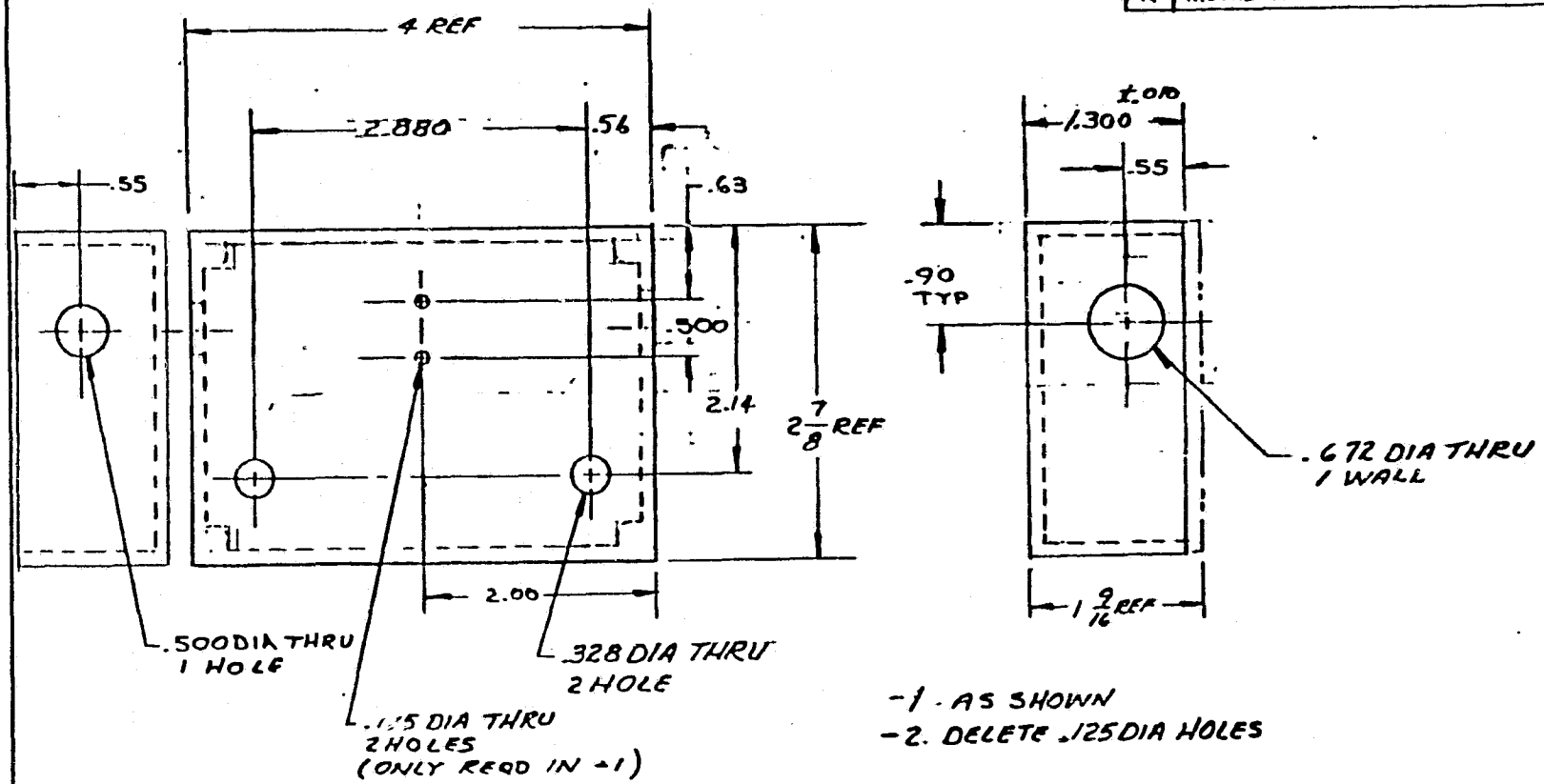
5. ALL LINES TO BE CENTERED

E-5175	Block B
NEXT ASSY	USED ON

Solar Power Corporation

SCALE: 1 : 1	APPROVED BY: D Dills 10/15/79	DRAWN BY: R.G. Landy
DATE: 10/15/79		
LABEL	DRAWING NUMBER: A-10458	B

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL
A	MOVED HOLES WAS 1.44 NOW 2.14 ADDED HOLES	4/8/80	PTHall



-1. AS SHOWN
-2. DELETE .125 DIA HOLES

NOTE:
1. REMOVE BURRS AND SHARP EDGES
2. MODIFY BOX AS SHOWN & REDRILL COVER MOUNTING HOLES

E5175	BLOCK II
NEXT ASSY	USED ON

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND DEGREES

TOLERANCES		SURFACES
ANGLES	±	MICRO INCHES
FRACTIONS	±	
2 PLACE	±.02	
3 PLACE	±.010	

FINISH

DR. [illegible] DATE 7/30
CHK. Dave Dib 5/21/80
APPD.
APPD.
REL.

MATERIAL
MAKE FROM
H.H. SMITH
P/N 2377

Solar Power Corporation

JUNCTION BOX
MODIFIED

SIZE B | 10529 | A

SCALE 1/1 | SHEET 1 OF 1

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL
A	DELETED TOL ±.02	5/29/80	P Thiel

ACRYLIC SHEET

24.00 X 47.50 X .005 THK

NOTES

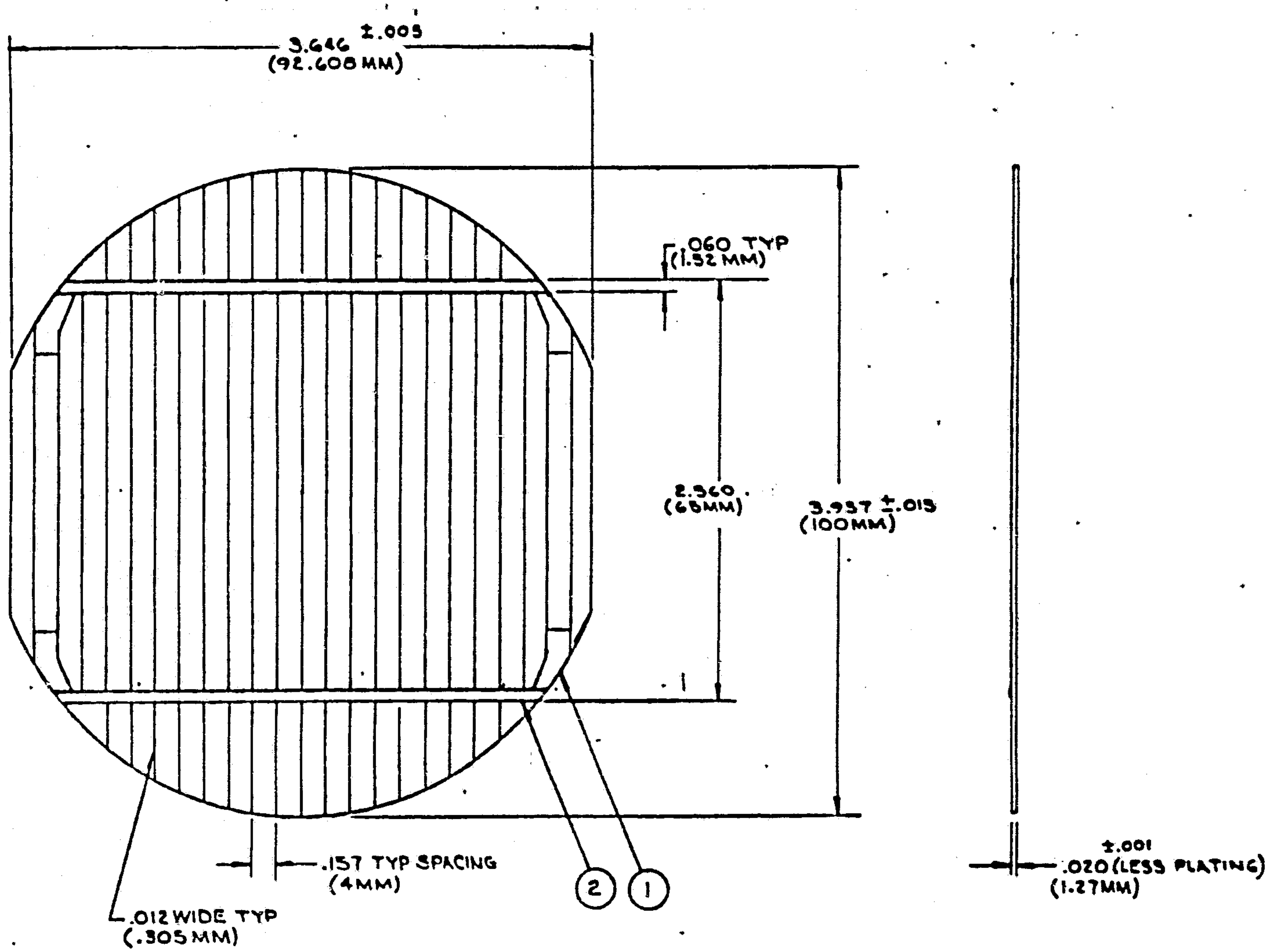
1. SOURCE OF SUPPLY
   EXCEL CORP
   290 FERRY ST
   NEWARK, N.J

5175	BLOCK II
NEXT ASSY	USED ON

Solar Power Corporation

SCALE: —	APPROVED BY: Dan Dills 3/25/80	DRAWN BY: P. Thiel
DATE: 2/8/80		
DIELECTRIC LAYER	DRAWING NUMBER: A-10530	REV A

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL
A	ADDED BL, DELETED INTERCONNECTS		



ITEM NO	QTY REQD	PART NO	DESCRIPTION
2	REF	C 7207	ARTWORK
1	1		SILCON WAFER

PARTS LIST

Solar Power Corporation

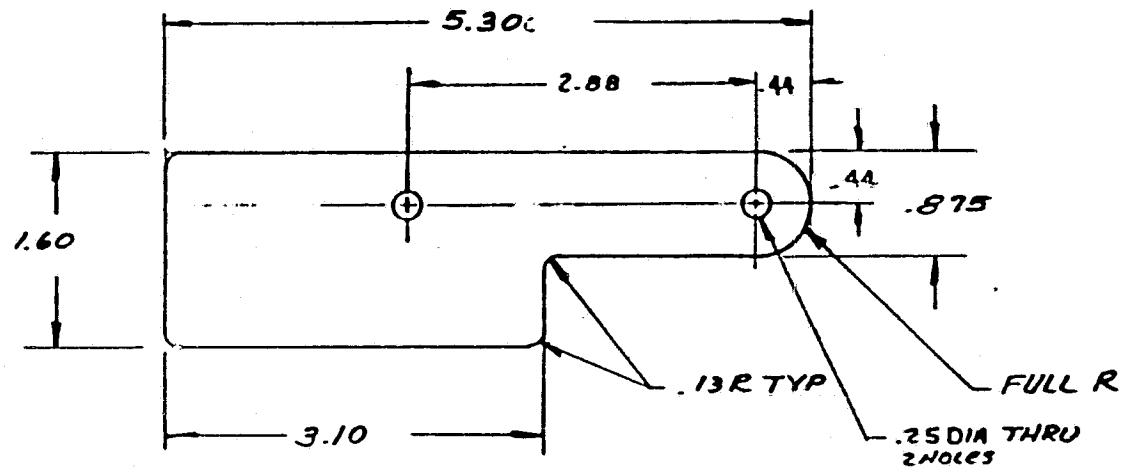
SOLAR CELL
BLOCK IV

SIZE		REV
C	10555	A

SCALE 2/1 SHEET 1 OF 1

E 5115	BLOCK II
NEXT ASSY	USED ON

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL
A	ADDED .25 DIA HOLES MATL WAS OFHC	4/7/80	PRJ



NOTE:

1. MATL: SOFT COPPER .002 THK

2. FINISH: 60/40 LEAD/TIN SOLDER BOTH SIDES
.0002 TO .0005 THK

15173	BLOCK IV
NEXT ASSY	USED ON

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND DEGREES

TOLERANCES		SURFACES
ANGLES	±	
FRACTIONS	±	
2 PLACE	±.05	MICRO INCHES
3 PLACE	±.02	

FINISH: NOTE 2

DR. P Tkachuk 17 Mar 80

CHK. Don Wilk 5/10/80

APPD

APPD.

REL

MATERIAL: NOTE 1

Solar Power Corporation

TERMINAL INTERCONNECT STRIP (BLOCK IV)

SIZE B | 10556 | REV. A

SCALE 1/1 | SHEET 1 OF 1

REVISIONS

LTR	DESCRIPTION	DATE	APPD
A	LENGTH WAS 22.50 NOW 21.13 ADDED TABLE I & -2	5/17/80	[illegible]

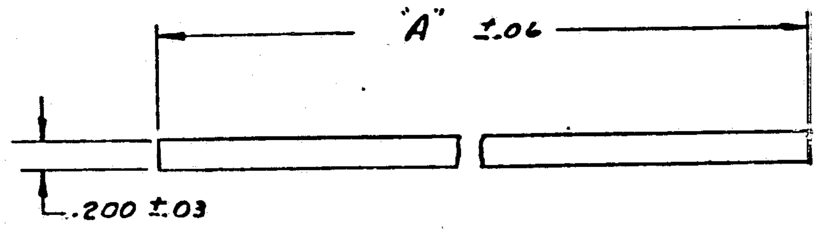


TABLE I	
PART NO	DIM "A"
10557-1	21.13
10557-2	2.00

NOTES
1. MATL: SOFT OFHC COPPER
   .010 THK
2. FINISH: 60/40 LEAD/TIN SOLDER
   PLATE BOTH SIDES .0002-.0005 THK

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND DEGREES	
TOLERANCES: ANGLES ± FRACTIONS ± 2 PLACE ± 3 PLACE ±	SURFACES: √ MICRO INCHES
FINISH: NOTE 2	MATERIAL: NOTE 1
DR. P. [illegible]	DATE 18 Mar 80
CHK. [illegible]	3/18/80
APPD.	
APPD.	
REL.	
NEXT ASSY: E 5175	USED ON: BLOCK IV

Solar Power Corporation

BUS STRIP

SIZE	DWG NO.	REV.
B	10557	A
SCALE 1/1	SHEET 1 OF 1	

REVISIONS			
LTR	DESCRIPTION	DATE	APPD
A	ADDED .025 DIM	5/29/…	PT

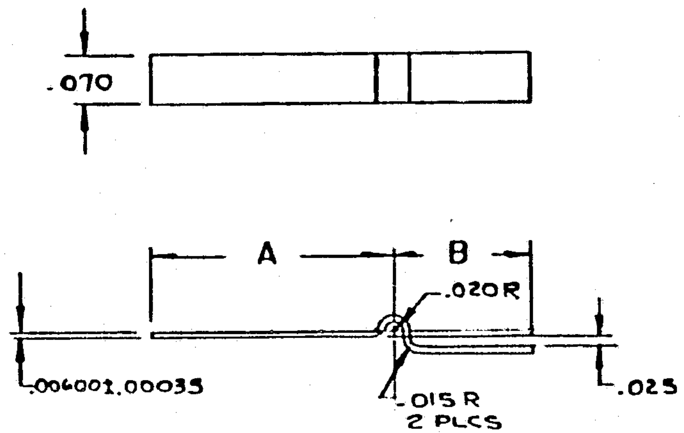


TABLE I		
PART NO	DIM A	DIM B
−1	3.10	.60
−2	3.10	2.30

NOTES.

1. MATERIAL: INVAR, ALLOY 36Ni, THICKNESS .0045 (1/2 HARD)
   SUGGESTED SOURCE
   POLYMETALLURGICAL CORP
   ATTELBORO FALLS, MA
2. FINISH: COPPER FLASH BOTH SIDE AND SOLDER PLATE TO OBTAIN TOTAL THICKNESS SHOWN

NEXT ASSY	USED ON
E5175	BLOCK IV

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND DEGREES

TOLERANCES: ANGLES ± / FRACTIONS ± / 2 PLACE ±.01 / 3 PLACE ±.005

SURFACES: MICRO INCHES

FINISH: SEE NOTE 2

DR. P. Theall (signature) DATE 17 Apr …
CHK. Don Dills (signature) 4/17/…
APPD.
APPD.
REL.

MATERIAL: SEE NOTE 1

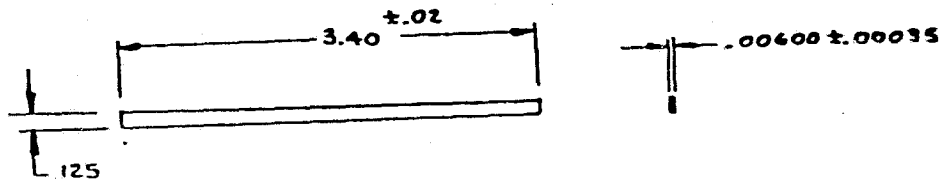
Solar Power Corporation

SOLAR CELL INTERCONNECT BARS

SIZE B | 10558 | REV. A

SCALE 1/1 | SHEET 1 OF 1

REVISIONS			
LTR	DESCRIPTION	DATE	APPD



NOTES:

1. MATL: INVAR, ALLOY 36Ni, THICKNESS .0045 (½HARD)
   SUGGESTED SOURCE
   POLYMETALLURGICAL CORP
   ATTELBORO FALLS, MA

2. FINISH: COPPER FLASH BOTH SIDE AND SOLDER PLATE
   BOTH SIDES TO OBTAIN TOTAL THICKNESS SHOWN

ESITS	BLOCK XX
NEXT ASSY	USED ON

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND DEGREES

TOLERANCES		SURFACES
ANGLES	±	✓ MICRO INCHES
FRACTIONS	±	
2 PLACE	±	
3 PLACE	±.005	

FINISH: SEE NOTE 2

DR. [signature] DATE 4/13/82

CHK. [signature] DATE 4/13/82

APPD.

APPD.

REL.

MATERIAL: SEE NOTE 1

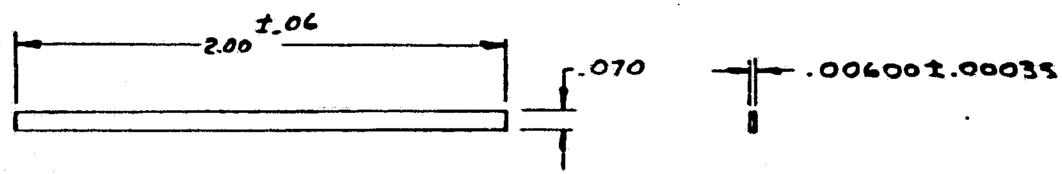
Solar Power Corporation

SOLAR CELL BOTTOM INTERCONNECT BAR

SIZE B | 10559 | REV. —

SCALE 1/1 | SHEET 1 OF 1

REVISIONS			
LTR	DESCRIPTION	DATE	APPD



NOTES

1. MATERIAL : INVAR, ALLOY 36Ni, THICKNESS .0045 (1/2 HARD)
   SUGGESTED SOURCE
   POLYMETALLURGICAL CORP
   ATTLEBORO FALLS, MA
2. FINISH: COPPER FLASH BOTH SIDES AND SOLDER
   PLATE TO OBTAIN TOTAL THICKNESS SHOWN

E5115	BLOCK IV
NEXT ASSY	USED ON

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND DEGREES

TOLERANCES: ANGLES ± / FRACTIONS ± / 2 PLACE ± / 3 PLACE ±

SURFACES: MICRO INCHES

FINISH: SEE NOTE 2

DR. [signature] DATE 19 May [illegible]

CHK. D. Dilk [illegible]

APPD.

APPD.

REL.

MATERIAL: SEE NOTE 1

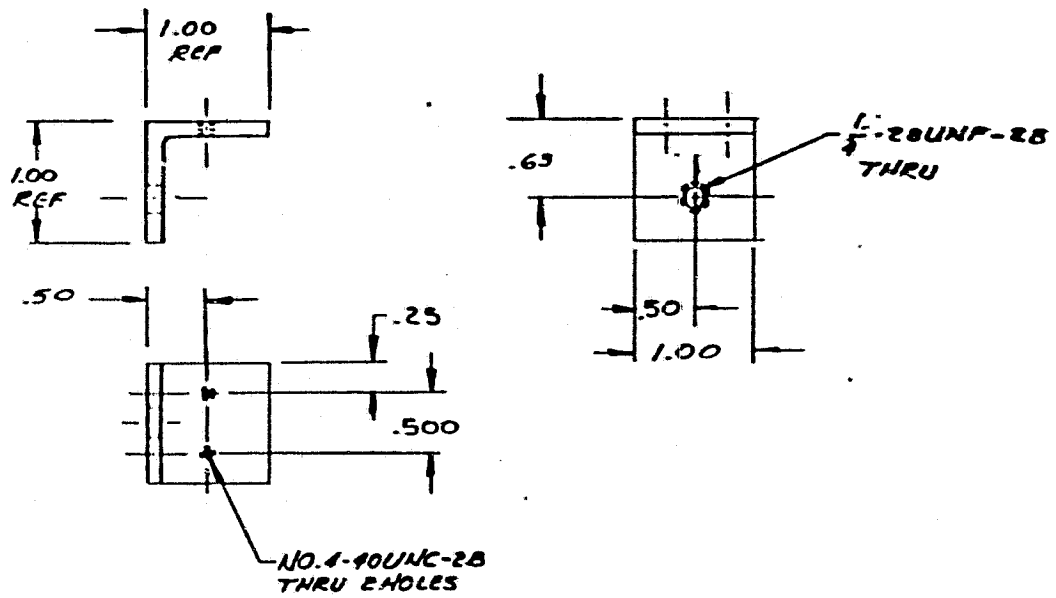
Solar Power Corporation

CELL BUS STRIP

SIZE B | 10598 | REV —

SCALE 2/1 | SHEET 1 OF 1

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL
A	V4-28UNF THRU WAS -257DIA	5/9/12	PTHall



B 5175	BOCK IX
NEXT ASSY	USED ON

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND DEGREES

TOLERANCES		SURFACES
ANGLES	±	MICRO INCHES
FRACTIONS	±	
2 PLACE	± .02	
3 PLACE	± .010	

FINISH

	DATE
DR. PThall	5/14/12
CHK. Dan Dutch	5/14/12
APVD.	
APVD.	
REL.	

MATERIAL
AL ANGLE 6061-T6
1"X1"X1/8 THK

Solar Power Corporation

DIODE MOUNTING BRACKET

SIZE		
B	10568	A

SCALE 1/1 SHEET 1 OF 1

APPENDIX A

QUALIFICATION TESTING AT JPL OF SOLAR POWER CORPORATION, MODEL 5175, BLOCK IV, INTERMEDIATE LOAD MODULES

As provided by the Contract, Article 1, Statement of Work, Paragraph (b)(3) and (b)(4), JPL conducted qualification testing on selected pre-production modules.

Prior to and immediately following each environmental test, an electrical performance test was conducted and a detailed visual inspection was performed by JPL Quality Assurance. The electrical performance tests were conducted in the JPL Large Area Pulsed Solar Simulator (LAPSS) using reference cell No. ZS-401.

The qualification tests were performed in accordance with Document 5101-16, Rev. A, entitled "Block IV Solar Cell Module Design and Test Specification For Intermediate Load Center Applications".

This report includes environmental test data (Table 1), electrical performance test data (Table 2) and applicable Problem/Failure reports.

The test results show that this module design did not meet the requirements of document 5101-16, Rev. A. Furthermore it is understood that Solar Power Corporation does not intend to continue the manufacture of this module design, Model No. 5175.

TABLE 1. Environmental Test Summary --
Solar Power Corp. Block IV Modules,
S/N's 5161, 6061, 6132, 6202

TEST	COMMENTS
o Thermal Cycling (50 cycles, -40 to +90°C)	Cell cracks, 3 modules. EVA delaminated & raised from enamelled pan above studs that hold back structural frame; also, in one case a J-box. Studs may be rapidly conducting heat from rear structure to EVA during Temp. cycling. Some cell cracks in other areas.
o Humidity Cycling (5 cycles)	1 module had 1 cell cracked 2 places.
o Mechanical Cycling (10,000 cycles)	1 module had laminate raised from substrate pan 3 places. 1 module had many cracks on 1 cell. Cell is over neg. terminal J-Box screw, 1 module had marginal electrical degradation and 2 edge cracks and 1 large chip on 1 cell.
o Twisted Surface	Satisfactory.
o Hail Impact (0.75 inch diam.)	Sensitivity sample S/N 6132 failed hail test as did S/N 5161. Hail test aborted.
o Final Electrical Voltage Isolation Test (2000 Vdc)	Satisfactory.

TABLE 2. Electrical Performance of the Four Environmentally Tested Modules (At 100 mW/cm^2 and 28°C)

TEST	Pmax (WATTS)	DELTA, Pmax (%)
Pre-Test		
S/N 5161	62.70	--
6061	64.41	--
6132	63.39	--
6201	62.15	--
Test Avg.	63.16	--
Post Thermal Cycle		
S/N 5161	62.60	-0.2
6061	63.95	-0.7
6132	62.94	-0.7
6201	60.76	-2.2
Test Avg.	62.56	-0.95
Post Humidity		
S/N 5161	60.74	-3.1
6061	63.81	-0.9
6132	62.88	-0.8
6201	62.48	+0.5
Test Avg.	62.48	-1.08
Post Mech. Cycling		
S/N 5161	60.93	-2.8
6061	63.17	-1.9
6132	62.50	-1.4
6201	59.95	-3.5
Test Avg.	61.64	-2.41
Post Twist		
S/N 5161	60.98	-2.7
6061	62.83	-2.5
6132	62.16	-1.9
6201	59.36	-4.5
Test Avg.	61.33	-2.90
Post Hail		
S/N 5161	61.06	-2.6
6061	Hail Test Not Performed	
6132	61.49	-3.0
6201	Hail Test Not Performed	
Test Avg.	61.28	-2.98

LSA PROJECT/FIELD ORGANIZATION PROBLEM/FAILURE REPORT

JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr. / Pasadena, Calif. 91103

2317

WRITTEN BY	REPORTING FACILITY	Bldg.	PROBLEM/FAILURE DATE	IR NO.
D. Hansen	JPL	#248	08/07/80	75401

MODULE DESCRIPTION	MFR	S/N	TEST ACTIVITY
Solar Power - Block IV	SLP	6061 60680-1	Post Temp. Cycling for 50 ~

FAILURE SITE (BLDG/APPLICATION): N/A

TIME IN FIELD/APPLICATION (YRS/MONTHS): N/A

2317

I. DESCRIPTION OF PROBLEM/FAILURE

(1) Qty 3 cells exhibit delamination on cell surface at interconnect.

*(2) Row 4, Cell #1 - Laminate raised under cell 35mm in dia. Cell exhibits numerous cracks from center of cell, one crack to cell edge.

*(3) Qty 3 cells exhibit edge cracks - Row 1, Cell #7 37mm LG: Row 4, Cell #12 30mm & 15mm LG: Row 6, Cell #5 25mm and 10mm LG.

*Does not meet Inspection System Plan.

II. VERIFICATION AND ANALYSIS

Analysis of the module problems resulting from environmental thermal and mechanical integrity tests can be attributed to differences in the coefficients of expansion of the various components of the module encapsulation system and the mechanical stability of the frame. The analysis report attached to PFR 2318 covers the various discrepancies and problems encountered as a result of the environmental tests.

CAUSE OF PROBLEM/FAILURE

☒ DESIGN ☐ WORKMANSHIP ☐ PIECE PART FAILURE ☐ MANUFACTURING ☐ DAMAGE (MISHANDLING) ☐ ADJUSTMENT ☐ OTHER _____

PERSON COMPLETING SECTION II	SIGNATURE	DATE
	Steve Sobbott	11-24-80

III. CORRECTIVE ACTION TAKEN

No corrective action required, manufacturer chooses not to continue with this module design.

DISPOSITION

☐ REWORKED ☐ REDESIGNED ☐ READJUSTED ☐ SCRAPPED ☐ RETESTED ☒ OTHER use as is

PERSON COMPLETING SECTION III	SIGNATURE	DATE	TASK MANAGER SIGNATURE	DATE
	R.F. Greenwood	12-9-80	L. Slunkle	12-9-80

JPL 2505 R 2/79

LSA PROJECT/FIELD ORGANIZATION PROBLEM/FAILURE REPORT

JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr. / Pasadena, Calif. 91103

2318

WRITTEN BY	REPORTING FACILITY		PROBLEM/FAILURE DATE	IR NO.
L. Elias	JPL	Bldg. #248	08-08-80	

MODULE DESCRIPTION	MFR	S/N	TEST ACTIVITY
Solar Power - Block IV	SLP	51680-1 5161	Post Temp. Cycling for 50 ~

FAILURE SITE (BLDG/APPLICATION)

TIME IN FIELD/APPLICATION (YRS/MONTHS)

2318

I. DESCRIPTION OF PROBLEM/FAILURE

*1) Numerous cracks on 2 cells Row 2 - Cell 1 - Cracks from Rim to Rim (Rim to Rim 9?mm) Row 3 - Cell 12 numerous cracks migrated from Rim to Rim crack found in Receiving Inspection - Laminate raised from substrate pan causing cracks.

*2) Corner of module top cover laminate delaminated 75mm by 30mm (Llumar Laminate).

3) Laminate raised from substrate pan by Row 2 - Cell 12.

*Does not meet Inspection System Plan.

II. VERIFICATION AND ANALYSIS

Analysis of the module problems resulting from environmental thermal and mechanical integrity tests can be attributed to differences in the coefficients of expansion of the various components of the module encapsulation system and the mechanical stability of the frame. The attached analysis report covers the various discrepancies and problems encountered as a result of the environmental tests.

CAUSE OF PROBLEM/FAILURE

☑ DESIGN ☐ WORKMANSHIP ☐ PIECE PART FAILURE ☐ MANUFACTURING ☐ DAMAGE (MISHANDLING) ☐ ADJUSTMENT ☐ OTHER _____

PERSON COMPLETING SECTION II	SIGNATURE	DATE
	Steve Sellers	11-24-80

III. CORRECTIVE ACTION TAKEN

No corrective action required, manufacturer chooses not to continue with this module design.

DISPOSITION

☐ REWORKED ☐ REDESIGNED ☐ READJUSTED ☒ SCRAPPED ☐ RETESTED ☐ OTHER

PERSON COMPLETING SECTION III	SIGNATURE	DATE	TASK MANAGER SIGNATURE	DATE
	R. F. Greenwood	12-9-80	L. E. Slaughter	12-4-80

JET PROPULSION LABORATORY

INTEROFFICE MEMORANDUM

3542:80:356

October 30, 1980

TO: Steve Sollock

FROM: John Repar John Repar

SUBJECT: Solar Power SXN 5180-1 (5161), PFT 2318

History

During receiving inspection, several discrepancies were noted. The hardware was loose on the structural assembly to the pan adjacent to the positive junction box. The washers were oversize on the pan mounting studs. Two solar cells had rim to rim cracks. In addition, there were sharp burrs on the edges of the structural assembly and the transparent cover film was loose along the module edges.

Following the temperature cycling test, cracks on two cells were detected and the encapsulant was delaminated from the substrate adjacent to one of the cells. Additional delamination of the cover film also occurred.

The humidity test was accompanied by two edge cracks on another of the cells.

Visual inspection after the mechanical integrity test revealed that delamination had occurred at three locations. The next test was a flex/twist of one cycle. No visual changes were observed.

The hail test consisted of three ice balls with a diameter of 3/4 inches striking the module at 45 mile per hour. Results were cracked cells in two of the impact areas.

The module failed the Hi-Pot test with the negative lead to the frame and the positive lead to the shorted terminals of the module at 390 volts. It passed the 2000 volt test when the leads were reversed.

Analysis

Visual inspection confirmed the location of the cracked cells. X-ray techniques were not sensitive enough to make them visible.

Distortion of the white EVA was noted at some of the sites where studs for bolting the frame to the module were located.

The cover film could be peeled from the top surface with relative ease.

The delamination which was visible following temperature and mechanical integrity tests had disappeared.

The module was subjected to one cycle of the temperature test (+90o through -40oC). No visible effects were noted through the window on the test chamber during the entire cycle.

Two of the cells were cut from the module. One had exhibited delamination during earlier temperature tests. The top two transparent layers of ethylene vinyl acetate could be separated readily from the white bottom layer in the area where delamination had been observed. The adhesion of the white layer to the porcelain surface was excellent.

Conclusions

The mechanical discrepancies such as loose hardware, sharp burrs, and incorecct washer size can be corrected easily.

Distortion of the white EVA suggests that the frame is attached to the module after the solar cells have been assembled on the substrate with the encapsulation system. When the nuts on the studs are tightened, they can also over stress the cells.

The occurrence of cracked cells in receiving inspection infers that better processing procedures are required. Subsequent cracking as the result of thermal and mechanical integrity tests can be attributed to differences in the coefficients of expansion of the various components and mechanical stability of the frame, respectively.

Delamination appeared during temperature cycling. Since it did not reappear during subsequent thermal testing, it is suspected that air was entrapped during initial assembly. Subsequent permeation of the air out of the gas pocket through the encapsulant would enable the optical coupling to be restored. The mechanical integrity test can be expected to result in delamination where adhesion between layers of encapsulant is low and the deflection is rather high.

Failure of the hail test requires additional engineering studies in order to optimize the design.

The electrical properties of this module design will be addressed in a separate report.

JR:lc

cc: C. Coulbert
C. Maag
H. Maxwell
B. Wada
LSA Data Center

O.K'd RRM.D
12-08-80

LSA PROJECT/FIELD ORGANIZATION PROBLEM/FAILURE REPORT

JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr / Pasadena, Calif. 91103

2319

WRITTEN BY	REPORTING FACILITY		PROBLEM/FAILURE DATE	IR NO.
L. Elias	JPL	Bldg. #248	08-08-80	75000

MODULE DESCRIPTION	MFR	S/N	TEST ACTIVITY
Solar Power - Block IV	SLP	6132 61380-2	Post Temp. Cycling for 50 ~

FAILURE SITE (BLDG/APPLICATION)

TIME IN FIELD/APPLICATION (YRS/MONTHS)

2319

I. DESCRIPTION OF PROBLEM/FAILURE

1) Qty of 2 cells exhibits rim to rim cracks
Row 5 - Cell 3 (110mm) Row 5 - Cell 10 (82mm)

*2) Qty of 4 cells exhibit laminate substrate pan causing cells to crack - Row 4 - Cell 3 edge crack 5mm, Row 4 - Cell 7 edge crack 23mm, Row 5 - Cell 12 numerous cracks longest 68mm and Row 6 - Cell 5 numerous cracks, longest 20mm.

*Does not meet Inspection System Plan.

II. VERIFICATION AND ANALYSIS

Analysis of the module problems resulting from environmental thermal and mechanical integrity tests can be attributed to differences in the coefficients of expansion of the various components of the module encapsulation system and the mechanical stability of the frame. The analysis report attached to PFR 2318 covers the various discrepancies and problems encountered as a result of the environmental tests.

CAUSE OF PROBLEM/FAILURE

☒ DESIGN ☐ WORKMANSHIP ☐ PIECE PART FAILURE ☐ MANUFACTURING ☐ DAMAGE (MISHANDLING) ☐ ADJUSTMENT ☐ OTHER _____

PERSON COMPLETING SECTION II	SIGNATURE	DATE
	Steve Sobleski	11-24-80

III. CORRECTIVE ACTION TAKEN

No corrective action required, manufacturer chooses not to continue with this module design.

DISPOSITION

☐ REWORKED ☐ REDESIGNED ☐ READJUSTED ☐ SCRAPPED ☐ RETESTED ☒ OTHER use as is

PERSON COMPLETING SECTION III	SIGNATURE	DATE	TASK MANAGER SIGNATURE	DATE
	K. T. Greenwood	12-9-80	L. E. Russell	12-9-80

JPL 2505 R 2/78

LSA PROJECT/FIELD ORGANIZATION PROBLEM/FAILURE REPORT

JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr. / Pasadena, Calif. 91103

2320

WRITTEN BY	REPORTING FACILITY		Bldg.	PROBLEM/FAILURE DATE	IR NO.
L. Elias	JPL		#248	08-18-80	74998
MODULE DESCRIPTION	**MFR**	**S/N**		**TEST ACTIVITY**	
Solar Power - Block IV	SLP	5161 51680-1		Post Humidity for 5 Cycles	
FAILURE SITE (BLDG/APPLICATION)					
TIME IN FIELD/APPLICATION (YRS/MONTHS)					

2320

I. DESCRIPTION OF PROBLEM/FAILURE

*1) Qty of 2 edge cracks at Row 4 - Cell 2
16mm and 42mm in length

*Does not meet Inspection System Plan

II. VERIFICATION AND ANALYSIS

Analysis of the module problems resulting from environmental thermal and mechanical integrity tests can be attributed to differences in the coefficients of expansion of the various components of the module encapsulation system and the mechanical stability of the frame. The analysis report attached to PFR 2318 covers the various discrepancies and problems encountered as a result of the environmental tests.

CAUSE OF PROBLEM/FAILURE

☒ DESIGN ☐ WORKMANSHIP ☐ PIECE PART FAILURE ☐ MANUFACTURING ☐ DAMAGE (MISHANDLING) ☐ ADJUSTMENT ☐ OTHER _____

PERSON COMPLETING SECTION II	SIGNATURE	DATE
	Steve Hollock	11-24-80

III. CORRECTIVE ACTION TAKEN

No corrective action required, manufacturer chooses not to continue with this module design.

DISPOSITION

☐ REWORKED ☐ REDESIGNED ☐ READJUSTED ☒ SCRAPPED ☐ RETESTED ☐ OTHER

PERSON COMPLETING SECTION III	SIGNATURE	DATE	TASK MANAGER SIGNATURE	DATE
	R. T. Greenwood	12-9-80	L. S. Dunkle	12-9-80

JPL 2505 R 2/79

LSA PROJECT/FIELD ORGANIZATION PROBLEM/FAILURE REPORT

JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr / Pasadena Calif 91103

2322

WRITTEN BY	REPORTING FACILITY	Bldg.	PROBLEM/FAILURE DATE	IR NO.
L. Elias	JPL	#248	08-22-80	74998

MODULE DESCRIPTION	MFR	S/N	TEST ACTIVITY
Solar Power - Block IV	SLP	5161 51680-1	10,000 Cycles. Post Mechanical Integrity for

FAILURE SITE (BLDG/APPLICATION)

TIME IN FIELD/APPLICATION (YRS/MONTHS)

I. DESCRIPTION OF PROBLEM/FAILURE

2322

1) Laminate raised from substrate pan at 3 locations
By Row 4 - Cell 3 and Row 4 - Cell 5 and at Row 3 - Cell 10

II. VERIFICATION AND ANALYSIS

Analysis of the module problems resulting from environmental thermal and mechanical integrity tests can be attributed to differences in the coefficients of expansion of the various components of the module encapsulation system and the mechanical stability of the frame. The analysis report attached to PFR 2318 covers the various discrepancies and problems encountered as a result of the environmental tests.

CAUSE OF PROBLEM/FAILURE

☒ DESIGN ☐ WORKMANSHIP ☐ PIECE PART FAILURE ☐ MANUFACTURING ☐ DAMAGE (MISHANDLING) ☐ ADJUSTMENT ☐ OTHER _____

PERSON COMPLETING SECTION II	SIGNATURE	DATE
	Steve Sobleck	11-24-80

III. CORRECTIVE ACTION TAKEN

No corrective action required, manufacturer chooses not to continue with this module design.

DISPOSITION

☐ REWORKED ☐ REDESIGNED ☐ READJUSTED ☒ SCRAPPED ☐ RETESTED ☐ OTHER

PERSON COMPLETING SECTION III	SIGNATURE	DATE	TASK MANAGER SIGNATURE	DATE
	R. F. Greenwood	12-9-80	L. L. Kazmerski	12-9-80

LSA PROJECT/FIELD ORGANIZATION PROBLEM/FAILURE REPORT

JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr. / Pasadena, Calif. 91103

2323

WRITTEN BY	REPORTING FACILITY	Bldg.	PROBLEM/FAILURE DATE	IR NO.
D. Hansen	JPL	#248	08-27-80	74996

MODULE DESCRIPTION	MFR	S/N	TEST ACTIVITY
Solar Power - Block IV	SLP	62080-1 6201	Post Mechanical Integrity 10,000 ~

FAILURE SITE (BLDG/APPLICATION)
N/A

TIME IN FIELD/APPLICATION (YRS/MONTHS)
N/A

2323

I. DESCRIPTION OF PROBLEM/FAILURE

Row 2, Cell #1 - 2 edge cracks 10mm LG and 50mm LG
Parallel to Collector - Edge chip 20mm LG X 1.5mm Deep.

II. VERIFICATION AND ANALYSIS

Analysis of the module problems resulting from environmental thermal and mechanical integrity tests can be attributed to differences in the coefficients of expansion of the various components of the module encapsulation system and the mechanical stability of the frame. The analysis report attached to PFR 2318 covers the various discrepancies and problems encountered as a result of the environmental tests.

CAUSE OF PROBLEM/FAILURE

☒ DESIGN ☐ WORKMANSHIP ☐ PIECE PART FAILURE ☐ MANUFACTURING ☐ DAMAGE (MISHANDLING) ☐ ADJUSTMENT ☐ OTHER _____

PERSON COMPLETING SECTION II	SIGNATURE	DATE
	Steve Sobbeke	11-24-80

III. CORRECTIVE ACTION TAKEN

No corrective action required, manufacturer chooses not to continue with this module design.

DISPOSITION

☐ REWORKED ☐ REDESIGNED ☐ READJUSTED ☐ SCRAPPED ☐ RETESTED ☒ OTHER use as is

PERSON COMPLETING SECTION III	SIGNATURE	DATE	TASK MANAGER SIGNATURE	DATE
	K. F. Hellwood	12-9-80	L. E. Quick	12-9-80

LSA PROJECT/FIELD ORGANIZATION PROBLEM/FAILURE REPORT

JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr. / Pasadena, Calif. 91103

2324

WRITTEN BY	REPORTING FACILITY	Bldg.	PROBLEM/FAILURE DATE	IR NO.
L. Elias	JPL	#248	08-27-80	75000

MODULE DESCRIPTION	MFR	S/N	TEST ACTIVITY
Solar Power - Block IV	SLP	6132 61380-2	Post Mech. Integrity for 10,000 ~

FAILURE SITE (BLDG/APPLICATION)

TIME IN FIELD/APPLICATION (YRS/MONTHS)

2324

I. DESCRIPTION OF PROBLEM/FAILURE

*1) Numerous cracks at Row 3 - Cell 12 over Junction Box

*Does not meet Inspection System Plan

II. VERIFICATION AND ANALYSIS

Analysis of the module problems resulting from environmental thermal and mechanical integrity tests can be attributed to differences in the coefficients of expansion of the various components of the module encapsulation system and the mechanical stability of the frame. The analysis report attached to PFR 2318 covers the various discrepancies and problems encountered as a result of the environmental tests.

CAUSE OF PROBLEM/FAILURE

☒ DESIGN ☐ WORKMANSHIP ☐ PIECE PART FAILURE ☐ MANUFACTURING ☐ DAMAGE (MISHANDLING) ☐ ADJUSTMENT ☐ OTHER _____

PERSON COMPLETING SECTION II	SIGNATURE	DATE
	Steve Gallook	11-24-80

III. CORRECTIVE ACTION TAKEN

No corrective action required, manufacturer chooses not to continue with this module design.

DISPOSITION

☐ REWORKED ☐ REDESIGNED ☐ READJUSTED ☐ SCRAPPED ☐ RETESTED ☒ OTHER use as is

PERSON COMPLETING SECTION III	SIGNATURE	DATE	TASK MANAGER SIGNATURE	DATE
	R. F. Greenwood	12-9-80	L. Elias	12-9-80

LSA PROJECT/FIELD ORGANIZATION PROBLEM/FAILURE REPORT

JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr / Pasadena, Calif 91103

2325

WRITTEN BY	REPORTING FACILITY	Bldg.	PROBLEM/FAILURE DATE	IR NO
D. Hansen	JPL	#248	09-09-80	74998

MODULE DESCRIPTION	MFR	S/N	TEST ACTIVITY
Solar Power - Block IV	SLP	5161	Post Hail Test

FAILURE SITE (BLDG/APPLICATION)
N/A

TIME IN FIELD/APPLICATION (YRS/MONTHS)
N/A

2325

I. DESCRIPTION OF PROBLEM/FAILURE

Module struck 3 times in 3 places with 3/4 inch Ice Balls - 45 MPH

(1) Row 3, Cells #6 and 7 - numerous edge cracks in impact area

(2) Row 4, Cell #5 - 7mm crack in impact area (Center of Cell)

II. VERIFICATION AND ANALYSIS

Cell cracking caused by the hail test using a 3/4 inch diameter Ice Ball at a velocity of 45 MPH points out a design deficiency which requires analysis to determine if such a design concept can be made viable.

CAUSE OF PROBLEM/FAILURE

☒ DESIGN ☐ WORKMANSHIP ☐ PIECE PART FAILURE ☐ MANUFACTURING ☐ DAMAGE (MISHANDLING) ☐ ADJUSTMENT ☐ OTHER _____

PERSON COMPLETING SECTION II	SIGNATURE	DATE
	Steve Selbak	11-24-80

III. CORRECTIVE ACTION TAKEN

No corrective action required as manufacturer has chosen not to go into production on this type module

DISPOSITION

☐ REWORKED ☐ REDESIGNED ☐ READJUSTED ☐ SCRAPPED ☐ RETESTED ☒ OTHER use as is

PERSON COMPLETING SECTION III	SIGNATURE	DATE	TASK MANAGER SIGNATURE	DATE
	K. T. Greenwood	12-9-80		12-9-80

APPENDIX B

FORMAT A

JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr. / Pasadena, Calif. 1101

PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] CIISF

A2 [Descriptive Name] Inspect, Test, and group cells

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] ICELL

A4 Descriptive Name [Product Name] Inspected & Tested Cell

A5 Unit Of Measure [Product Units] Cell

PART 2 – PROCESS CHARACTERISTICS

A6 [Output Rate] (Not Thruput) 8 Units (given on line A5) Per Operating Minute

A7 Average Time at Station [Processing Time] 5 Calendar Minutes (Used only to compute in-process inventory)

A8 Machine "Up" Time Fraction [Usage Fraction] .98 Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS [Machine Description]

A9	Component [Referent]	ASTATION	BSTATION	
A9a	Component [Descriptive Name] (Optional)	Xenon Test	Scope	
A10	Base Year For Equipment Prices [Price Year]	1977	1977	
A11	Purchase Price ($ Per Component) [Purchase Cost]	38,000	600	
A12	Anticipated Useful Life (Years) [Useful Life]	12	25	
A13	[Salvage Value] ($ Per Component)	18,000	350	
A14	[Removal and Installation Cost] ($/Component)	1,200	100	

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) CINSP

PART 4 – DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
A2064D	100.0	Sq. Ft.	Floor Space
B3720D	1.0	Person	Inspector

PART 5 – DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

	A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
	E1608D	0.0090	$	Spare Parts
	C1032B	.011	FW-HR/MIN	Electricity
*	E1140D	.06283	Sq. Meters	Solar Cells

PART 6 – INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
None			/	
			/	
			/	

Prepared by D. Dilts Date 7/7/80

* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

SOLAR ARRAY MANUFACTURING INDUSTRY COSTING STANDARDS

FORMAT A

JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr. / Pasadena, Calif 91103

PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] CSTRING

A2 [Descriptive Name] Cell Stringing

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] STCELLS

A4 Descriptive Name [Product Name] String Cells 12S x 6P

A5 Unit Of Measure [Product Units] String

PART 2 – PROCESS CHARACTERISTICS

A0	[Output Rate] (Not Thruput)	.022	Units (given on line A5) Per Operating Minute
A7	Average Time at Station [Processing Time]	45	Calendar Minutes (Used only to compute in-process inventory)
A8	Machine "Up" Time Fraction [Usage Fraction]	.95	Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS [Machine Description]

A9	Component [Referent]	FIXTURE		
A9a	Component [Descriptive Name] (Optional)	FXT		
A10	Base Year For Equipment Prices [Price Year]	1977		
A11	Purchase Price ($ Per Component) [Purchase Cost]	400		
A12	Anticipated Useful Life (Years) [Useful Life]	5		
A13	[Salvage Value] ($ Per Component)	0		
A14	[Removal and Installation Cost] ($/Component)	0		

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) CSTRING

PART 4 – DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
B3032D	1	Person	Operator/Assembler
A2064D	16.0	Sq. ft.	Floor Space

PART 5 – DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
E1608D	.00015	$/Min	Spare Parts
C1032B	.035	KW Hr/Min	Electricity
ECD06D	.08	Connectors/Min	Connectors
EA4D	1.98 E-03	lb/Min	Buss Bar
EG54D	.528	ft.	Copper Mesh

PART 6 – INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

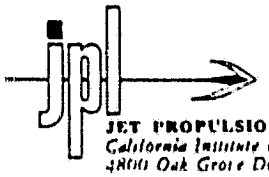
A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
ICELL	99.9	.0139	String/Cell	
			/	
			/	

Prepared by D. Dilts Date 7/7/80

* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

SOLAR ARRAY MANUFACTURING INDUSTRY COSTING STANDARDS

FORMAT A



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PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] STRINSP

A2 [Descriptive Name] Inspect, Test, String

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] ISTRING

A4 Descriptive Name [Product Name] Inspected String

A5 Unit Of Measure [Product Units] String

PART 2 – PROCESS CHARACTERISTICS

A6	[Output Rate] (Not Thruput)	.1	Units (given on line A5) Per Operating Minute
A7	Average Time at Station [Processing Time]	10	Calendar Minutes (Used only to compute in-process inventory)
A8	Machine "Up" Time Fraction [Usage Fraction]	.99	Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS [Machine Description]

A9	Component [Referent]	ISTATION		
A9a	Component [Descriptive Name] (Optional)	Optical		
A10	Base Year For Equipment Prices [Price Year]	1977		
A11	Purchase Price ($ Per Component) [Purchase Cost]	350		
A12	Anticipated Useful Life (Years) [Useful Life]	12		
A13	[Salvage Value] ($ Per Component)	200		
A14	[Removal and Installation Cost] ($/Component)	0		

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) STRINSP

PART 4 – DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
A2192I	24.0	Sq. Ft.	Floor Space
B3720D	0.8	Person	Inspector

PART 5 – DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
C1032B	.012	KW-Hrs/Min	Electricity

PART 6 – INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
STCELLS	100	1.0	String/String	
			/	
			/	

Prepared by D. Dilts Date 7/8/80

* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

SOLAR ARRAY MANUFACTURING INDUSTRY COSTING STANDARDS

FORMAT A

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PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] MPREP

A2 [Descriptive Name] Clean, Prime, Module Components

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] PMOD

A4 Descriptive Name [Product Name] Prepared Module Components

A5 Unit Of Measure [Product Units] Components

PART 2 – PROCESS CHARACTERISTICS

A6 [Output Rate] (Not Thruput) .65 Units (given on line A5) Per Operating Minute

A7 Average Time at Station [Processing Time] 2 Calendar Minutes (Used only to compute in-process inventory)

A8 Machine "Up" Time Fraction [Usage Fraction] 1.0 Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS [Machine Description]

A9	Component [Referent]	None		
A9a	Component [Descriptive Name] (Optional)			
A10	Base Year For Equipment Prices [Price Year]			
A11	Purchase Price ($ Per Component) [Purchase Cost]			
A12	Anticipated Useful Life (Years) [Useful Life]			
A13	[Salvage Value] ($ Per Component)			
A14	[Removal and Installation Cost] ($/Component)			

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) MPREP

PART 4 – DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
A2064D	32.0	Sq. ft.	Floor Space
B3080D	0.8	Person	Mod. Assembler

PART 5 – DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
E1516D	.062	lbs/Min	Primer
E1352D	.050	lbs/Min	Alcohol

PART 6 – INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
ISTRING	99.0	1.0	String/Components	
			/	
			/	

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* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

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PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] MASSY

A2 [Descriptive Name] Assemble Mod. Layers

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] AMOD

A4 Descriptive Name [Product Name] Layed up Module

A5 Unit Of Measure [Product Units] Module

PART 2 – PROCESS CHARACTERISTICS

A6 [Output Rate] (Not Thruput) .125 Units (given on line A5) Per Operating Minute

A7 Average Time at Station [Processing Time] 8 Calendar Minutes (Used only to compute in-process inventory)

A8 Machine "Up" Time Fraction [Usage Fraction] 1.0 Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS [Machine Description]

A9	Component [Referent]	None		
A9a	Component [Descriptive Name] (Optional)			
A10	Base Year For Equipment Prices [Price Year]			
A11	Purchase Price ($ Per Component) [Purchase Cost]			
A12	Anticipated Useful Life (Years) [Useful Life]			
A13	[Salvage Value] ($ Per Component)			
A14	[Removal and Installation Cost] ($/Component)			

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) MASSY

PART 4 – DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
A2064D	20	Sq. ft.	Floor Space
B3080D	.5	Person	Mod. Assembler

PART 5 – DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
E1254D	.215	lbs/Min	EVA
E1808D	2.0	sq. ft.	Crane Glas
E1360D	.06	lbs/Min	Acrylic
E1608D	.0025	$/Min	Spare Parts
E1512D	1	sq. ft.	Substrate
EG30D	1	ft^2	Mylar

PART 6 – INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
PMOD	99.0	1.0	Module /Module	
			/	
			/	

Prepared by D. Dilts Date 7/7/80

* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

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FORMAT A

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PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] XMASSY

A2 [Descriptive Name] Assemble Mod, Layers

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] AMOD

A4 Descriptive Name [Product Name] Layed up Module

A5 Unit Of Measure [Product Units] Module

PART 2 – PROCESS CHARACTERISTICS

A6 [Output Rate] (Not Thruput) .125 Units (given on line A5) Per Operating Minute

A7 Average Time at Station [Processing Time] 8 Calendar Minutes (Used only to compute in-process inventory)

A8 Machine "Up" Time Fraction [Usage Fraction] 1.0 Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS [Machine Description]

A9	Component [Referent]	None		
A9a	Component [Descriptive Name] (Optional)			
A10	Base Year For Equipment Prices [Price Year]			
A11	Purchase Price ($ Per Component) [Purchase Cost]			
A12	Anticipated Useful Life (Years) [Useful Life]			
A13	[Salvage Value] ($ Per Component)			
A14	[Removal and Installation Cost] ($/Component)			

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) XMASSY

PART 4 – DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
A2064D	20	sq. ft.	Floor Space
B3080D	.5	Person	Mod. Assembler

PART 5 – DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
E1254D	.215	lbs/Min	EVA
E1808D	2.0	sq. ft.	Crane Glass
E1360D	.06	lbs/Min	Acrylic
E1608D	.0025	$/Min	Spare Parts
E1514D	1	sq. ft.	Substrate
EG30D	1	ft^2	Mylar

PART 6 – INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
PMOD	99.0	1.0	Module /Module	
			/	
			/	

Prepared by D. Dilts Date 7/7/80

* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

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PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] MLAM

A2 [Descriptive Name] Laminate Module

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] LMOD

A4 Descriptive Name [Product Name] Laminated Module

A5 Unit Of Measure [Product Units] Module

PART 2 – PROCESS CHARACTERISTICS

A6 [Output Rate] (Not Thruput) .10 Units (given on line A5) Per Operating Minute

A7 Average Time at Station [Processing Time] 45 Calendar Minutes (Used only to compute in-process inventory)

A8 Machine "Up" Time Fraction [Usage Fraction] .90 Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS (Machine Description)

A9	Component [Referent]	PRESS		
A9a	Component [Descriptive Name] (Optional)	Pneumatic		
A10	Base Year For Equipment Prices [Price Year]	1978		
A11	Purchase Price ($ Per Component) [Purchase Cost]	11,000		
A12	Anticipated Useful Life (Years) [Useful Life]	10		
A13	[Salvage Value] ($ Per Component)	5,000		
A14	[Removal and Installation Cost] ($/Component)	500		

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) MLAM

PART 4 – DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
A2064D	20	sq. ft.	Floor Space
B3080D	.4	Person	Mod. Assembler

PART 5 – DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
C1032B	.85	KWHR/Min	Electricity
E1608D	.150	$	Spare Parts
C1128D	2.01	cu ft/Min	Water

PART 6 – INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
AMOD	99.8	1.0	Module/Module	
			/	
			/	

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* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

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PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] IMLAM

A2 [Descriptive Name] Laminate Module

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] ILMOD

A4 Descriptive Name [Product Name] Laminated Modules

A5 Unit Of Measure [Product Units] Modules

PART 2 – PROCESS CHARACTERISTICS

A6	[Output Rate] (Not Thruput)	.60	Units (given on line A5) Per Operating Minute
A7	Average Time at Station [Processing Time]	45	Calendar Minutes (Used only to compute in-process inventory)
A8	Machine "Up" Time Fraction [Usage Fraction]	.95	Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS (Machine Description)

A9	Component [Referent]	IPRESS		
A9a	Component [Descriptive Name] (Optional)	6 Rotary Pneumatic		
A10	Base Year For Equipment Prices [Price Year]	1980		
A11	Purchase Price ($ Per Component) [Purchase Cost]	68,000		
A12	Anticipated Useful Life (Years) [Useful Life]	15		
A13	[Salvage Value] ($ Per Component)	26,000		
A14	[Removal and Installation Cost] ($/Component)	1,000		

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) IMLAM

PART 4 – DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
A2064D	110	sq. ft.	Floor Space
B3080D	1.8	Person	Mod. Assembler

PART 5 – DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
C1032B	2.0	KW HR/Min	Electricity
E1608D	.150	$	Spare Parts
C1128D	10	cu ft	Water

PART 6 – INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
AMOD	99.8	1.0	Module/Module	
			/	
			/	

Prepared by D. Dilts Date 7/7/80

* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

SOLAR ARRAY MANUFACTURING INDUSTRY COSTING STANDARDS

FORMAT A

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PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] JBOX

A2 [Descriptive Name] Assemble J-Box and Diodes

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] JMOD

A4 Descriptive Name [Product Name] Module with J Box

A5 Unit Of Measure [Product Units] Module

PART 2 – PROCESS CHARACTERISTICS

A6	[Output Rate] (Not Thruput)	.2	Units (given on line A5) Per Operating Minute
A7	Average Time at Station [Processing Time]	6	Calendar Minutes (Used only to compute in-process inventory)
A8	Machine "Up" Time Fraction [Usage Fraction]	1.0	Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS [Machine Description]

A9	Component [Referent]	None		
A9a	Component [Descriptive Name] (Optional)			
A10	Base Year For Equipment Prices [Price Year]			
A11	Purchase Price ($ Per Component) [Purchase Cost]			
A12	Anticipated Useful Life (Years) [Useful Life]			
A13	[Salvage Value] ($ Per Component)			
A14	[Removal and Installation Cost] ($/Component)			

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) JBOX

PART 4 – DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
A2064D	32.0	sq. ft.	Floor Space
B3080D	0.4	Person	Mod. Assembler

PART 5 – DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
EG39D	.2	Sets/Min	Terminal Blocks
EX007D	.2	Diode/Min	Diodes
E1608D	.05	$	Spare Parts
E1552D	.04	lbs/Min	RTV 108

PART 6 – INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
LMOD	99	1.0	Mod / J-Box — Mod	
			/	
			/	

Prepared by D. Dilts Date 7/7/80

* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

SOLAR ARRAY MANUFACTURING INDUSTRY COSTING STANDARDS

FORMAT A

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PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] IJBOX

A2 [Descriptive Name] Assemble J-Box and Diodes

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] JMOD

A4 Descriptive Name [Product Name] Module with J Box

A5 Unit Of Measure [Product Units] Module

PART 2 – PROCESS CHARACTERISTICS

A6	[Output Rate] (Not Thruput)	.2	Units (given on line A5) Per Operating Minute
A7	Average Time at Station [Processing Time]	6	Calendar Minutes (Used only to compute in-process inventory)
A8	Machine "Up" Time Fraction [Usage Fraction]	1.0	Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS [Machine Description]

A9	Component [Referent]	None		
A9a	Component [Descriptive Name] (Optional)			
A10	Base Year For Equipment Prices [Price Year]			
A11	Purchase Price ($ Per Component) [Purchase Cost]			
A12	Anticipated Useful Life (Years) [Useful Life]			
A13	[Salvage Value] ($ Per Component)			
A14	[Removal and Installation Cost] ($/Component)			

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) IJBOX

PART 4 – DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
A2064D	32.0	Sq. ft.	Floor Space
B3080D	0.4	Person	Mod. Assembler

PART 5 – DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
EG39D	.2	Sets/Min	Terminal Blocks
EX007D	.2	Diode/Min	Diodes
E1608D	.05	$	Spare Parts
E1552D	.04	lbs/Min	RTV 108

PART 6 – INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
ILMOD	99	1.0	Mod /J-Box	Mod
			/	
			/	

Prepared by D. Dilts Date 7/7/80

* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

SOLAR ARRAY MANUFACTURING INDUSTRY COSTING STANDARDS

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PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] MODTEST

A2 [Descriptive Name] Electrical Per/ormance TEst

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] TESTM

A4 Descriptive Name [Product Name] Tested Module

A5 Unit Of Measure [Product Units]

PART 2 – PROCESS CHARACTERISTICS

A6	[Output Rate] (Not Thruput)	.60	Units (given on line A5) Per Operating Minute
A7	Average Time at Station [Processing Time]	4	Calendar Minutes (Used only to compute in-process inventory)
A8	Machine "Up" Time Fraction [Usage Fraction]	.98	Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS [Machine Description]

A9	Component [Referent]	FLASHER		
A9a	Component [Descriptive Name] (Optional)	Xenon-Pulse		
A10	Base Year For Equipment Prices [Price Year]	1977		
A11	Purchase Price ($ Per Component) [Purchase Cost]	120,000		
A12	Anticipated Useful Life (Years) [Useful Life]	16		
A13	[Salvage Value] ($ Per Component)	12,000		
A14	[Removal and Installation Cost] ($/Component)	2,500		

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) MODTEST

PART 4 – DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
B3784D	1	Persor	Tester
A2064D	100	sq. ft.	Floor Space

PART 5 – DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
E1608D	.09	$	Spare Parts
C1032B	.001	KW HR/Min	Electricity

PART 6 – INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
JMOD	99.9	1.0	Module /Module	
			/	
			/	

Prepared by D. Dilts Date 7/7/80

* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

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PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] MINSP

A2 [Descriptive Name] Final Inspection

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] FMOD

A4 Descriptive Name [Product Name] Finished Module

A5 Unit Of Measure [Product Units] Modules

PART 2 – PROCESS CHARACTERISTICS

A6	[Output Rate] (Not Thruput)	.2	Units (given on line A5) Per Operating Minute
A7	Average Time at Station [Processing Time]	17	Calendar Minutes (Used only to compute in-process inventory)
A8	Machine "Up" Time Fraction [Usage Fraction]	.98	Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS [Machine Description]

A9	Component [Referent]	ISCOPE		
A9a	Component [Descriptive Name] (Optional)	Optical		
A10	Base Year For Equipment Prices [Price Year]	1977		
A11	Purchase Price ($ Per Component) [Purchase Cost]	500		
A12	Anticipated Useful Life (Years) [Useful Life]	20		
A13	[Salvage Value] ($ Per Component)	200		
A14	[Removal and Installation Cost] ($/Component)	0		

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) MINSP

PART 4 — DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
B3720D	1.5	Person	Inspector Q.C.
A2064D	120	sq. ft.	Floor Space

PART 5 — DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
C1032B	0.009	KW-HR/Min	Electricity
D1208D	0.003	Modules/Min	Reject Modules

PART 6 — INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
TESTM	99	1	Module/Module	
			/	
			/	

Prepared by D. Dilts Date 7/7/80

* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

SOLAR ARRAY MANUFACTURING INDUSTRY COSTING STANDARDS

FORMAT A

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PROCESS DESCRIPTION

Note: Names given in brackets [ ] are the names of process attributes requested by the SAMIS III computer program.

A1 Process [Referent] PAK

A2 [Descriptive Name] Crate Modules

PART 1 – PRODUCT DESCRIPTION

A3 [Product Referent] MPAK

A4 Descriptive Name [Product Name] Packaged Module 10/crate

A5 Unit Of Measure [Product Units] Crate

PART 2 – PROCESS CHARACTERISTICS

A6	[Output Rate] (Not Thruput)	.028	Units (given on line A5) Per Operating Minute
A7	Average Time at Station [Processing Time]	45	Calendar Minutes (Used only to compute in-process inventory)
A8	Machine "Up" Time Fraction [Usage Fraction]	1.0	Operating Minutes Per Minute

PART 3 – EQUIPMENT COST FACTORS [Machine Description]

A9	Component [Referent]	None		
A9a	Component [Descriptive Name] (Optional)			
A10	Base Year For Equipment Prices [Price Year]			
A11	Purchase Price ($ Per Component) [Purchase Cost]			
A12	Anticipated Useful Life (Years) [Useful Life]			
A13	[Salvage Value] ($ Per Component)			
A14	[Removal and Installation Cost] ($/Component)			

Note: The SAMIS III computer program also prompts for the [payment float interval], the [inflation rate table], the [equipment tax depreciation method], and the [equipment book depreciation method]. In the LSA SAMICS context, use 0.0, (1975, 6.0), DDB, and SL.

Format A: Process Description (Continued)

A15 Process Referent (From Page 1 Line A1) PAK

PART 4 – DIRECT REQUIREMENTS PER MACHINE (Facilities) OR PER MACHINE PER SHIFT (Personnel)
[Facilities and Personnel Requirements]

A16 Catalog Number [Expense Item Referent]	A18 Amount Required Per Machine (Per Shift) [Amount per Machine]	A19 Units	A17 Requirement Description
B3640D	1	Person	Packager
A2064D	200	sq. ft.	Floor Space

PART 5 – DIRECT REQUIREMENTS PER MACHINE PER MINUTE
[Byproduct Outputs] and [Utilities and Commodities Requirements]

A20 Catalog Number [Expense Item Referent]	A22 Amount Required Per Machine Per Minute [Amount per Cycle]	A23 Units	A21 Requirement Description
E1180D	.56	cu ft/Min	Crates

PART 6 – INTRA-INDUSTRY PRODUCT(S) REQUIRED [Required Products]

A24 [Product Reference]	A28 [Yield]* (%)	A26 [Ideal Ratio]** Of Units Out/Units In	A27 Units Of A26***	A25 Product Name
FMOD	99.9	.1	Crates/Module	
			/	
			/	

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* 100% minus percentage of required product lost.
** Assume 100% yield here.
*** Examples: Modules/Cell or Cells/Wafer.

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FORMAT B — COMPANY DESCRIPTION

Company Referent: SOL-1

DESCRIPTIVE NAME: SOLAR POWER GENERATION CO.

10 KW

0.	(b)	(Final) Product(s) Produced	Modules in Crates (MPAK)
	(a)	(Final) Process(es)	PAK
	(c)	Ideal Ratio(s) with units	0.1 Crate/Module
1.	(b)	Intermediate Product(s)	FMOD
	(a)	Process(es)	MINSP
	(c)	Ideal Ratio(s) with units	1 module/module
2.	(b)	Intermediate Product(s)	TESTM
	(a)	Process(es)	MODTEST
	(c)	Ideal Ratio(s) with units	0.5 Mod/J Box
3.	(b)	Intermediate Product(s)	JMOD
	(a)	Process(es)	JBOX
	(c)	Ideal Ratio(s) with units	1 module/module
4.	(b)	Intermediate Product(s)	ILMOD
	(a)	Process(es)	IMLAM
	(c)	Ideal Ratio(s) with units	1 Module/Module
5.	(b)	Intermediate Product(s)	LMOD
	(a)	Process(es)	MLAM
	(c)	Ideal Ratio(s) with units	1 Module/Module
6.	(b)	Intermediate Product(s)	AMOD
	(a)	Process(es)	MASSY
	(c)	Ideal Ratio(s) with units	1 String/Module
7.	(b)	Intermediate Product(s)	PMOD
	(a)	Process(es)	MPREP
	(c)	Ideal Ratio(s) with units	1 String/String
8.	(b)	Intermediate Product(s)	ISTRING
	(a)	Process(es)	STRINSP
	(c)	Ideal Ratio(s) with units	.0139 String/Cell
9.	(b)	Intermediate Product(s)	STCELLS
	(a)	Process(es)	CSTRING
	(c)	Ideal Ratio(s) with units	1 Cell/Cell
		Purchased Product(s)	ICELL
		Supplier and Percentage	CINSP
		Supplier and Percentage	

PREPARED BY: D. Dirk

DATE: 7/4/80

FORMAT B — COMPANY DESCRIPTION

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Company Referent SOL-2

DESCRIPTIVE NAME

SOLAR POWER GENERATION CO.

100 KW

0.	(b)	(Final) Product(s) Produced	Modules in Crates (MPAK)
	(a)	(Final) Process(es)	PAK
	(c)	Ideal Ratio(s) with units	0.1 Crate/Module
1.	(b)	Intermediate Product(s)	FMOD
	(a)	Process(es)	MINSP
	(c)	Ideal Ratio(s) with units	1 Module/Module
2.	(b)	Intermediate Product(s)	TESTM
	(a)	Process(es)	MODTEST
	(c)	Ideal Ratio(s) with units	0.5 Mod/J Box
3.	(b)	Intermediate Product(s)	JMOD
	(a)	Process(es)	IJBOX
	(c)	Ideal Ratio(s) with units	1 Module/Module
4.	(b)	Intermediate Product(s)	ILMOD
	(a)	Process(es)	IMLAM
	(c)	Ideal Ratio(s) with units	1 Module/Module
5.	(b)	Intermediate Product(s)	LMOD
	(a)	Process(es)	MLAM
	(c)	Ideal Ratio(s) with units	1 Module/Module
6.	(b)	Intermediate Product(s)	AMOD
	(a)	Process(es)	MASSY
	(c)	Ideal Ratio(s) with units	1 String/Module
7.	(b)	Intermediate Product(s)	PMOD
	(a)	Process(es)	MPREP
	(c)	Ideal Ratio(s) with units	1 String/String
8.	(b)	Intermediate Product(s)	ISTRING
	(a)	Process(es)	STRINSP
	(c)	Ideal Ratio(s) with units	.0139 String/Cell
9.	(b)	Intermediate Product(s)	STCELLS
	(a)	Process(es)	CSTRING
	(c)	Ideal Ratio(s) with units	1 Cell/Cell
		Purchased Product(s)	ICELL
		Supplier and Percentage	CINSP
		Supplier and Percentage	

PREPARED BY D. Dilts

DATE 7/4/80

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FORMAT B — COMPANY DESCRIPTION

Company Referent

SOL-3

DESCRIPTIVE NAME

SOLAR POWER GENERATION CO.

1000 KW

0.	(b)	(Final) Product(s) Produced	Modules in Crates (MPAK)
	(a)	(Final) Process(es)	PAK
	(c)	Ideal Ratio(s) with units	0.1 Crate/Module
1.	(b)	Intermediate Product(s)	FMOD
	(a)	Process(es)	MINSP
	(c)	Ideal Ratio(s) with units	1 Module/Module
2.	(b)	Intermediate Product(s)	TESTM
	(a)	Process(es)	MODTEST
	(c)	Ideal Ratio(s) with units	0.5 Mod/M Box
3.	(b)	Intermediate Product(s)	JMOD
	(a)	Process(es)	IJBOX
	(c)	Ideal Ratio(s) with units	1 Module/Module
4.	(b)	Intermediate Product(s)	ILMOD
	(a)	Process(es)	IMLAM
	(c)	Ideal Ratio(s) with units	1 Module/Module
5.	(b)	Intermediate Product(s)	LMOD
	(a)	Process(es)	MLAM
	(c)	Ideal Ratio(s) with units	1 Module/Module
6.	(b)	Intermediate Product(s)	AMOD
	(a)	Process(es)	XMASSY
	(c)	Ideal Ratio(s) with units	1 String/Module
7.	(b)	Intermediate Product(s)	PMOD
	(a)	Process(es)	MPREP
	(c)	Ideal Ratio(s) with units	1 String/String
8.	(b)	Intermediate Product(s)	ISTRING
	(a)	Process(es)	STRINSP
	(c)	Ideal Ratio(s) with units	.013? String/Cell
9.	(b)	Intermediate Product(s)	STCELLS
	(a)	Process(es)	CSTRING
	(c)	Ideal Ratio(s) with units	1 Cell/Cell
		Purchased Product(s)	ICELL
		Supplier and Percentage	CINSP
		Supplier and Percentage	

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DATE 7/4/80

SOLAR ARRAY MANUFACTURING INDUSTRY COSTING STANDARDS

FORMAT C

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INDUSTRY DESCRIPTION

C1 Industry Referent PHOTVOLT

C2 Description (Optional) Photovoltaic Power Generation

INDUSTRY OBJECTIVE

C3 Industry Result Modules

C4 Quantity Produced 10 Kilowatts/Yr.

DESCRIPTION OF THE FINAL PRODUCT OF THE INDUSTRY

C5 Reference Modules Name Packaged Module 10 per Crate

C6 Production is Measured in Kilowatts per Year

C7 Hardware Performance .548 (C4 per C6)

C8 Product Design Description (Optional)

MAKERS OF THE FINAL PRODUCT OF THE INDUSTRY

C9 Company Reference -- Market Share --

Company Reference -- Market Share --

Company Reference -- Market Share --

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SOLAR ARRAY MANUFACTURING INDUSTRY COSTING STANDARDS

FORMAT C

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INDUSTRY DESCRIPTION

C1 Industry Referent APHOTOVOL

C2 Description (Optional) Photovoltaic Power Generation

INDUSTRY OBJECTIVE

C3 Industry Result Modules

C4 Quantity Produced 100 Kilowatts/Yr.

DESCRIPTION OF THE FINAL PRODUCT OF THE INDUSTRY

C5 Reference Modules Name Packaged Modules 10 per Crate

C6 Production is Measured in Kilowatts/Yr.

C7 Hardware Performance .548 (C4 per C6)

C8 Product Design Description (Optional) ----

MAKERS OF THE FINAL PRODUCT OF THE INDUSTRY

C9 Company Reference --- Market Share ---

Company Reference --- Market Share ---

Company Reference --- Market Share ---

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